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GLASSY CARBONS

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SUMMARY

Measurements by a variety of methods of structural characteristics at size levels from atomic dimensions to the macroscopic, together with the resulting mechanical and physical properties have shown that porous glassy carbons achieved by pyrolysis of furfural alcohol resins can reproducibly and rapidly be produced in large sections with tailored properties of potential interest for mechanical, physical and chemical applications. Sections greater than three inches have been made in pyrolysis cycles of one day.

Thermodynamic cell measurements of the configurational enthalpy and entropy difference between glassy carbons and graphite have shown that the fine structures of various glassy carbons are quite different and certainly not merely microcrystalline graphite. The entropy measurements show that a large configurational difference exists relative to graphite for any of the glassy carbons studied up to the highest treatment temperature studied (about 1900°C). In addition, these data show that not much additional order is produced during vacuum pyrolysis in the temperature range of 1300°C to 1900°C even though there is a continuous sharpening of the wide angle X-ray spectrum. The strain as measured by the configurational enthalpy drops rapidly and continuously for the pyrolysis range studied (1000-1900°C).

An analysis of the thermodynamics of the C-O-H system shows that the presence of rather large amounts of hydrogen contamination would be required in order to measurably affect the thermodynamic cell measurements of enthalpy and entropy.

Small angle X-ray scattering measurements under improved experimental conditions have shown excellent agreement with other such work on commercial glassy carbon samples. However, many experimental glassy carbons show a markedly different fine pore structure. In many cases the very fine pore structure (10-100A) is not monodisperse, but appears to be distributed throughout the range.

While strength is roughly proportional to increased apparent density and inversely proportional to macro pore size (100A and above), many notable exceptions exist. The reasons apparently lie in the very fine structure, most probably in variations possible in the polydispersity of very fine scale pores. A rather strong inverse relation exists between the compressive strength and electrical resistivity, reduced by calculation to eliminate all pores open to xylene, indicating that better layer perfection leads to higher strength.

GLASSY CARBONS

I. Introduction

This report covers work carried out during the period June 1973 to January 1974. Results of the previous contract periods are summarized in four previous semi-annual reports[1]. Since various property evaluations are being carried out simultaneously, the data tables included in this report are cumulative and have been revised to reflect additional samples as well as corrected in certain instances where more reliable measurements were obtained. Cumulative data tables are given in the Appendix.

The term glassy carbon has been used in recent years to describe a supposedly new form of carbon having generally very high strength, hardness and inertness, coupled with a low density and a black glassy appearing fracture surface. Its properties are rather dramatically different from those of graphite and diamond and therefore has lead to interest in developing materials for a wide variety of structural, wear resistant, high temperature, biomedical, corrosion resistant, electrical, and chemical separation applications. While glassy carbons are all made by a controlled decomposition of organic compounds it has become obvious that the properties obtained depend markedly on the nature of the organic precursor and the exact details of its decomposition.

In short, glassy carbon is not a single material but a class of materials having a range of structure at all size levels ranging from atomic to macroscopic dimensions. While the materials normally produced are nearly pure carbon, because of the variability in structure they may possess quite different properties. In most respects these materials may be considered as two dimensional polymers containing a vanishingly small content of atoms other than carbon. Crystal structure in a three dimensional sense is lacking and even the two dimensional structure is not perfect. These materials are not truly amorphous in the sense of a supercooled random liquid but they are highly disordered and at best can be thought of as paracrystalline. With respect to their small scale structure they are really not new materials since they seem to be similar in many ways to soots, carbon blacks, and hard coals. In addition the so-called "graphite" fibers have a structure much more closely related to a one dimensionally elongated glassy carbon than to crystalline graphite. In addition most of the matrix materials in carbon-carbon composites are disordered rather than graphitic.

Since the structure is so variable on all size levels, no single tool for investigation is satisfactory for revealing the complete structure. The current program utilized, bright and dark field electron microscopy, scanning microscopy, small and wide angle X-ray diffraction, pycnometry, porosimetry, surface adsorption, hardness, strength, modulus of elasticity, electrical

resistivity and thermodynamic methods to gain information about both the void and the solid structure. After examining many different samples with these techniques it was concluded that the most important information could be gained from a newly developed thermodynamic method for characterizing the degree of order of the solid together with small angle X-ray diffraction for characterizing the small voids and scanning microscopy and density measurements for the larger scale structure.

A complete picture of the small scale structure gleaned from the many different studies suggest that glassy carbons are made up of highly strained and twisted stacks of about five randomly oriented planes with an approximate graphite structure within each plane. In addition, a small amount of rather large crystalline areas (up to 1 micron) with either graphite or diamond structure can be found. Even though the small scale structure is two dimensional the macroscopic properties are isotropic. Probably the most interesting feature of the structure is the incorporation of relatively stable voids within the structure on a size scale from atomic dimensions to the macroscopic. The control of this void system in both size and amounts leads to an interesting ability to tailor all of the physical, chemical and mechanical properties over wide ranges.

II. Materials Preparation

An original goal of this program was to produce thick sections, i.e., greater than 1/8 inch, in short processing times

without cracking. This goal has been met by incorporating a pore system to relieve escaping gases during the early stages of pyrolysis. Section sizes up to three inches have been successfully prepared in pyrolysis cycles of about one day.

In the last period the major effort has been aimed at reproducibility in preparation. To that end some 110 separate batches were processed with a minimum number of process variations. Provided meticulous care is exercised at all stages, reproducibility in structure and properties can be achieved. Attempts to further refine preparation techniques with the currently favored precursor resin (Durez) and PTSA catalyst system are being made. It appears obvious that other resin systems would require at least as much effort in optimizing preparation in order to achieve the most desireable properties.

III. Structural Studies

The structural studies have concentrated in two areas, refinement and extension of the thermodynamic characterization of disorder, and small angle X-ray scattering for investigation of the small pores.

In the case of the thermodynamics, a significant extension has been made in analyzing the potential effect of hydrogen included in the system. The small angle X-ray work has concentrated on achieving agreement with results of other laboratories, refining experimental techniques and improved analyses of the data.

A. Thermodynamic Characterization

Additional data were obtained on the Gibbs free energy change of the equilibrium:

$$C_{graphite} = C_{glassy\ carbon}$$

for a series of glassy carbon samples 324-19, varying only in HTT (highest heat treating temperatures). This measurement as a function of temperature allows the evaluation of both the configurational enthalpy and entropy. The first gives a measure of the energies of missing atoms, strained bonds and similar defects while the second relates to the disorder relative to perfect crystalline graphite.

The measurement currently employed measures electrochemically the difference between graphite and glassy carbon maintained in their respective equilibrium oxygen partial pressures at a given temperature and atmospheric pressure. Table 1 lists the summary of thermal treatment for all the glassy carbon samples studied so far by both fused salt (FS) and solid electrolyte (ZC) techniques. The samples were heated in either vacuum ($\simeq 5\times10^{-7}$ atm) or in an atmosphere of flowing nitrogen for about 1 hr at HTT selected between 1000°-2000°C. The plots of free energy change ΔG vs. T for the reaction $C_{graphite} = C_{glassy\ carbon}$ yielded straight lines, since the above reaction involves vanishingly small differences in composition, specific heat, and hence the vibrational contributions. Figure 1 shows the ΔG vs. temperature

TABLE 1: Summary of Thermal Treatment on Glassy Carbon Samples

Experiment	Sample #	HTT (°C)	HTt (hr.)	HTT Atmosphere (Vacuum $\simeq 5\times10^{-7}$ atms.)
FS-2	321-10	1600	≃ 1	Nitrogen
FS-5	321-7	1400	≃ 1	Nitrogen
FS-9	321-9	1600	≃ 1	Nitrogen
FS-11	321-7	1600	≃ 1	Nitrogen
ZC-15	UCAR-ZBY	*	*	*
ZC-16	321-13	1060	≃ 1	Vacuum
ZC-17	321-13	1243	≃ 1	Vacuum
ZC-18	321-13	1510	≃ 1	Vacuum
ZC-19	321-13	1800	≃ 1	Vacuum
ZC-21	Beckwith D-82-2	2000	*	*
ZC-23	321-13	2000	≃ 1	Nitrogen
ZC-24	321-7	1002	≃ 1	Vacuum
ZC-25	321-7	2000	≃ 1	Nitrogen
ZC-27	Hercules H-54	1795	≃ 1	Vacuum
ZC-28	324-19	1066	≃ 1	Vacuum
ZC-29	324-19	1250	≃ 1	Vacuum
ZC-30	324-19	1550	≃ 1	Vacuum
ZC-31	324-19	1890	≃ 1	Vacuum

*Not known

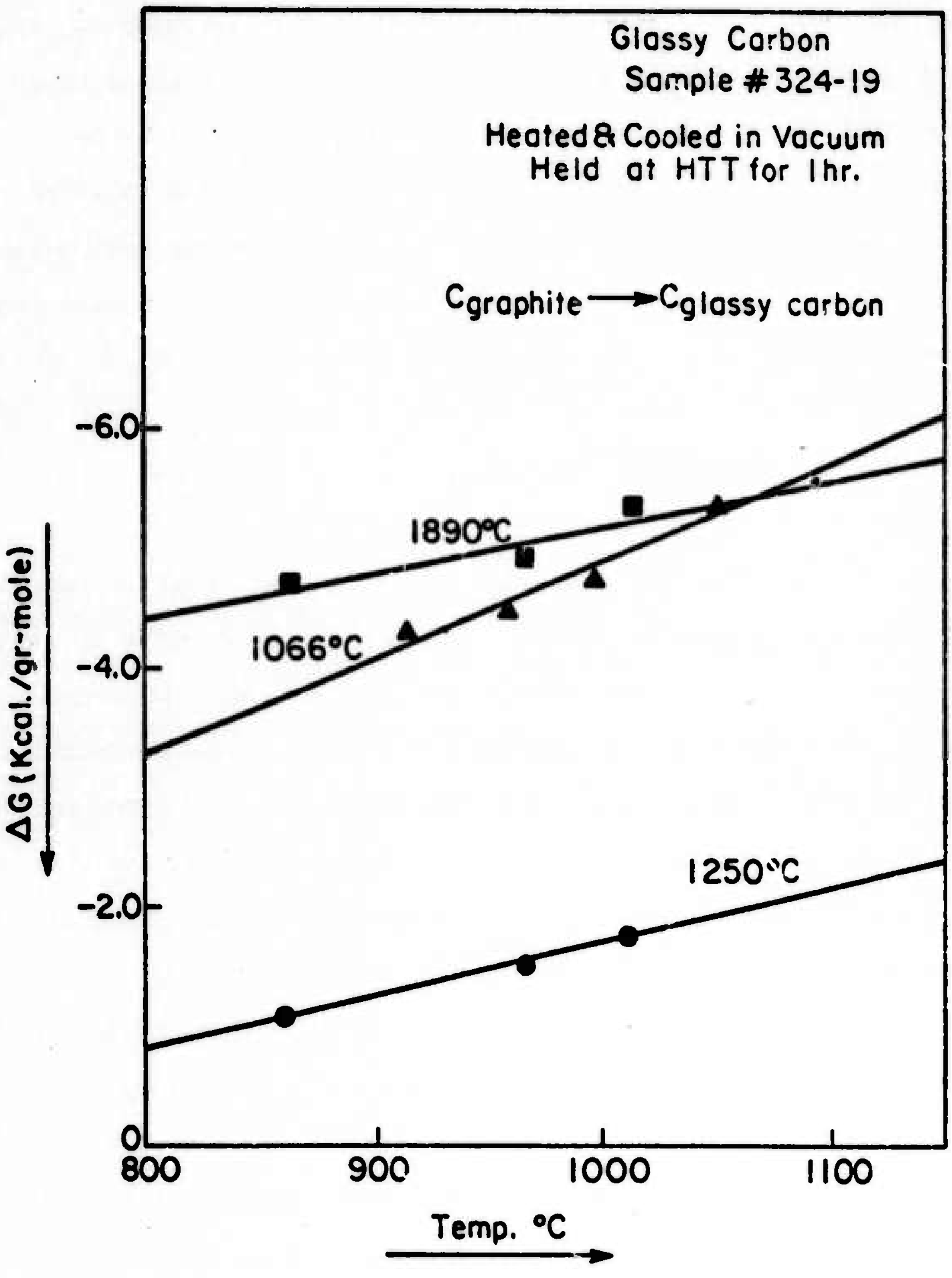

Figure 1. Free Energy-Temperature Relationship for 324-19 Series Glassy Carbons

plots for the 324-19 series glassy carbon varying only in HTT. The slopes and intercepts at absolute zero of the lines yield the respective values of configurational entropy and enthalpy. A summary of data obtained on all the glassy carbon samples obtained so far has been presented in Table 2. As it can be seen, excellent least-square fits have been obtained on raw data of most of the glassy carbon samples, i.e., standard deviation of about 100-300 cal/gr-mole and correlation coefficients exceeding 0.99 in most cases. This uncertainty is well within the achievement domain of solid oxide electrolyte cells.

The information contained in Table 2 is also presented in Fig. 2 in a graphical form, which may be regarded as a two-parameter (ΔS and ΔH) representation of glassy carbon samples. On this plot the origin represents perfect crystalline hexagonal graphite. It is quite apparent that the various glassy carbon samples are remarkably different in thermodynamic properties which manifests in a wide range of physical, mechanical and structural properties. This justifies our contention that "glassy" carbon is not a single material, but a family of materials whose structure (hence the properties) can be varied at all size levels.

Additional data for nitrogen surface area, Xylene density, L_c, d_{002}, L_a, d_{10} on the samples used for thermodynamic study have been summarized in Table 3. Figure 3 shows the results on the 324-19 series glassy carbon. The entropy and enthalpy show the expected trend, decreasing with increasing HTT. It is appar-

TABLE 2: Summary of Data on Thermodynamic Measurements

Experiment	ΔH (cal/gr-mole)	ΔS (cal/gr-mole-°K)	Standard Deviation in ΔG (cal/gr-mole)	Correlation Coefficient
FS-2	200	0.2	±100	0.957
FS-5	8,900	7.5	±100	0.999
FS-9	1,300	1.4	----	-----
FS-11	750	0.6	±100	0.999
ZC-15	300	0.2	----	-----
ZC-16	9,200	8.8	±100	0.990
ZC-17	4,800	4.6	±100	0.999
ZC-18	4,200	4.2	±100	0.998
ZC-19	3,700	4.6	±100	0.994
ZC-21	5,200	10.5	±200	0.997
ZC-23	7,000	5.1	±200	0.995
ZC-24	2,750	3.1	±100	0.998
ZC-25	4,500	7.7	±100	0.994
ZC-27	4,500	11.3	±200	0.995
ZC-28	5,600	8.3	±300	0.969
ZC-29	4,050	4.5	±100	0.997
ZC-31	300	4.3	±300	0.937

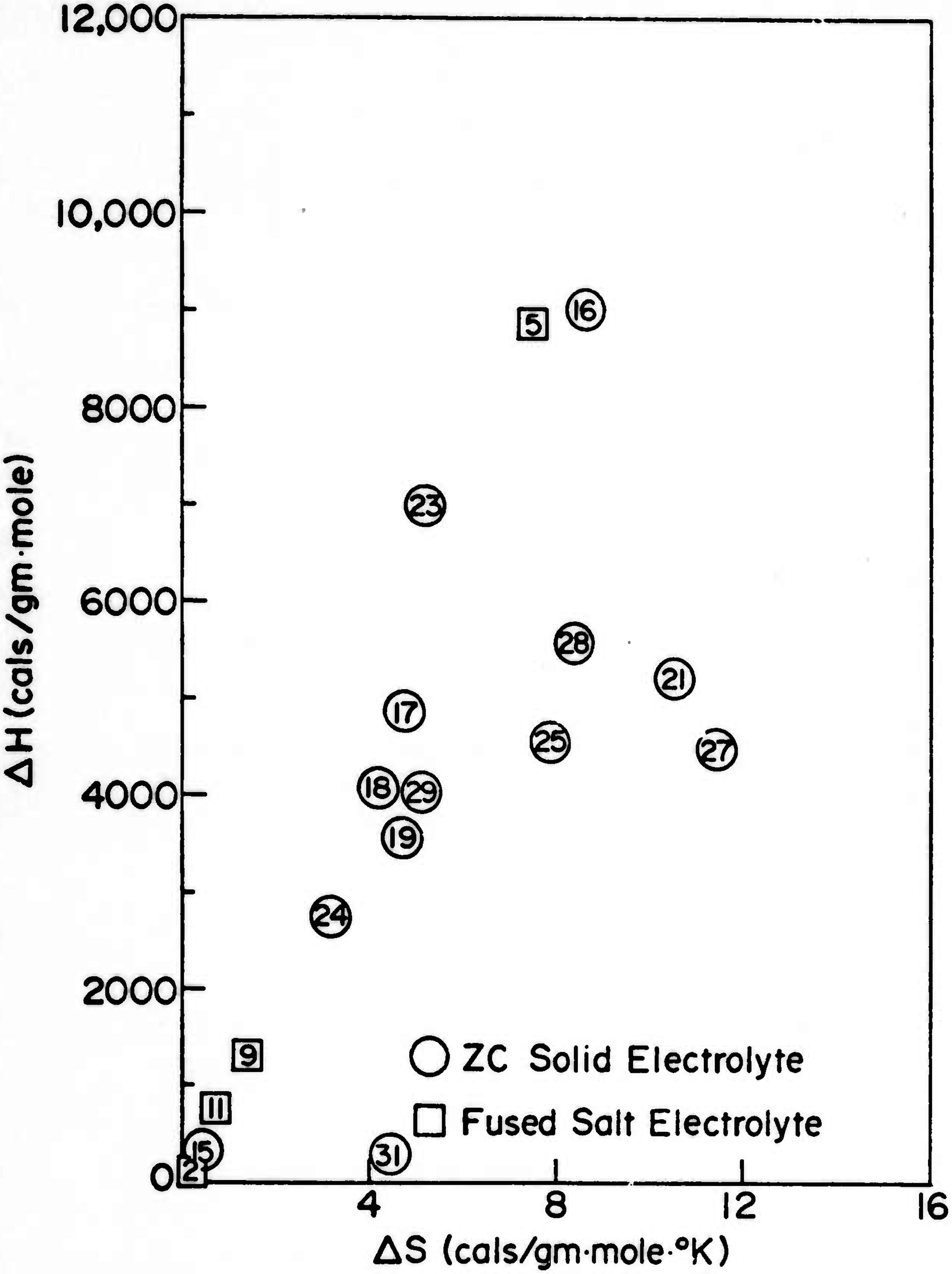

Figure 2. Two parameter representation of Glassy Carbons

TABLE 3: Summary of X-ray, Surface Area, and Xylene Density Data

Experiment	Specific Nitrogen Surface Area m^2/gr	Xylene Density ρ_{XYL}, gr/cc	d_{002} Å	L_c Å	d_{10} Å	L_a Å
Graphite	----	2.22	3.37	Very high	2.13	Very high
ZC-16	72.4	1.56	3.70	16.5	No vis. peak	No vis. peak
ZC-17	56.6	1.54	3.63	18.1	2.09	47.5
ZC-18	51.3	1.50	3.63	18.1	2.09	39.4
ZC-19	47.9	1.44	3.56	18.5	2.10	48.5
ZC-21	----	1.51	3.49	30.8	2.10	48.5
ZC-23	----	1.45	3.42	32.2	2.09	61.0
ZC-24	----	1.52	3.69	17.5	No vis. peak	No vis. peak
ZC-25	----	1.47	3.46	30.8	2.10	42.0
ZC-27	----	1.51	3.49	28.0	2.09	51.0
ZC-28	----	1.71	3.63	16.5	2.08	40.0
ZC-29	----	1.66	3.63	15.4	2.07	35.8
ZC-30	----	1.60	3.63	18.8	2.09	51.0
ZC-31	----	1.55	3.56	22.4	2.08	57.3

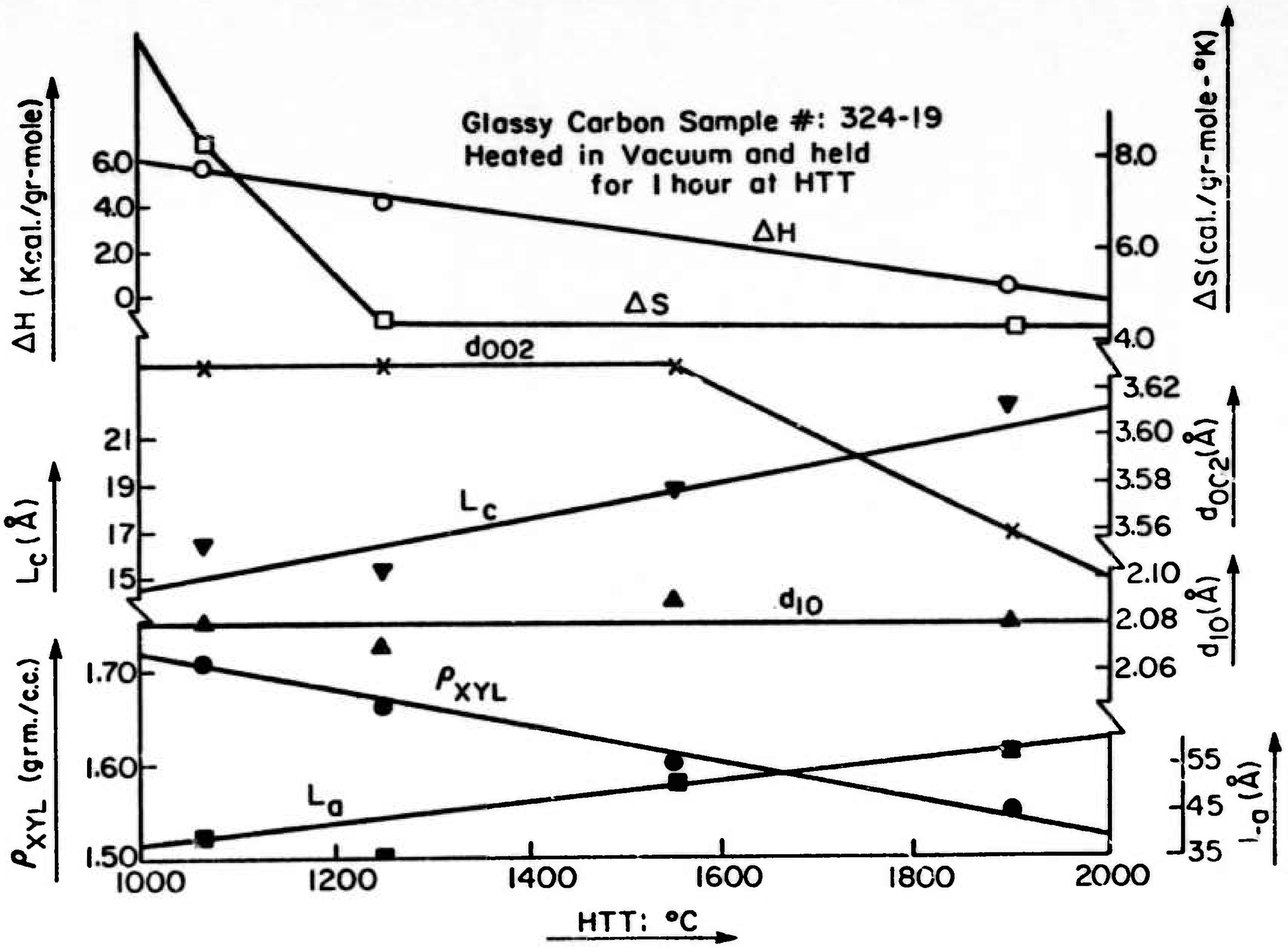

Figure 3. Relation of X-ray, density and thermodynamic data in 324-19 Series Glassy Carbons.

ent that relatively minor changes occur from 1250°-1900°C. The enthalpy drops more rapidly than the entropy in this range. The enthalpy difference, ΔH for the sample 324-19-1890°C (ZC-31) is only 300 cal/gr-mole which represents one of the smallest values obtained thus far indicating bond energy remarkably close to that for graphite. However, the configurational entropy shows that the structural order changes very little and is grossly different than crystalline graphite.

The X-ray data correlate roughly in this series with the thermodynamic measurements. However, d_{002} shows a significant change while the atomic configuration is almost constant. This may well be due to strain relaxation which is confirmed by the lowering of ΔH to 300 cal/gr-mole. The values of L_a and L_c steadily increase with increasing HTT while d_{10} is fairly constant. These findings are consistent with the formation of closed pores as indicated by the steady drop in xylene density.

B. Effect of Hydrogen on Thermodynamic Measurements

The experimental data obtained thus far on the thermodynamics of carbons were treated for a C-O binary system. The effect of a small amount of hydrogen present in the glassy carbon or graphite was a-priori assumed to be negligible, and the entire thermodynamic development of C-O-H ternary was approximated by the C-O limiting binary. This section describes the effects of hydrogen content on the thermodynamics of carbon approximated by the C-O binary. The variations of experimentally measured equilibrium oxygen partial pressure, activity of carbon, and the emf of the galvanic cell to measure the above quantities, have been studied as the function of hydrogen content. Since there is no available experimental data or approximating theoretical model to calculate the equilibrium hydrogen pressure of a given carbon from the input hydrogen concentration [i.e., the reaction: $\frac{1}{2}H_2(g) \rightleftarrows \underline{H}$ (hydrogen structurally associated in carbon)], the parameter studied is the <u>input or initial hydrogen content</u> of the system. Although the major source of hydrogen input is the carbon sample, the present calculation assumes a total hydrogen input from all sources, i.e., carbon sample, purified gas, adsorbed moisture, and minute but finite undetected leaks.

<u>Method of Solution</u>

The three component system of C-H-O, has one condensed phase C, and six gaseous constituents, CO, CO_2, H_2, H_2O, O_2 and

CH_4, considering only one major hydrocarbon constituent, methane, and hence four independent chemical reactions (no. of constituents - no. of elements = 7-3 = 4) will completely and uniquely describe the equilibrium of C-H-O ternary system. The four chemical reactions chosen were those where direct and accurate experimental data for equilibrium constants exists in the literature[2]. The reactions and the value of their equilibrium constants are as follows:

Reaction	Equilibrium Constant log K
I. $C(S) + \frac{1}{2}O_2(g) = CO(g)$	$(5956/T) + 4.459$
II. $C(S) + O_2(g) = CO_2(g)$	$(20590/T) + 0.0437$
III. $H_2(g) + \frac{1}{2}O_2(g) = H_2O(g)$	$(13045/T) - 2.981$
IV. $C(S) + 2H_2(g) = CH_4(g)$	$(4796/T) - 5.805$

Assuming that the gaseous constituents form an ideal solution, their fugacities can be approximated by partial pressures which can in turn be replaced by mole fractions, at 1 atmospheric pressure. The equilibrium constants, K_I, K_{II}, K_{III} and K_{IV} for the above reactions can thus be expressed, independent of total systems pressure as:

$$K_I = \frac{p_{CO}}{(a_c)(p_{O_2}^{1/2})}$$

$$K_{II} = \frac{p_{CO_2}}{(a_c)(p_{O_2})}$$

$$K_{III} = \frac{p_{H_2O}}{(p_{H_2})(p_{O_2}^{1/2})}$$

$$K_{IV} = \frac{p_{CH_4}}{(a_c)(p_{H_4})^2}$$

However, three additional constraints must be provided to solve the system of seven unknowns and seven equations uniquely. The four equilibrium constants constitute the first four equations. The fifth equation is the statement that the summation of partial pressures of all the constituents in the gaseous phase equals the total pressure of one atmosphere. The experimentally measured value, A, of the oxygen partial pressure of the C-O-H system constitutes the sixth equation. The seventh and the final equation comes from the conservation of hydrogen atoms, i.e., total input hydrogen, B, is split into equilibrium hydrogen, water vapor, and methane.

The resulting seven non-linear equations may be written in the form:

$$f_i(x) = 0, \qquad i = 1,2,\ldots 7 \tag{1}$$

$$f_1(x) = x_1^2 - (K_I)^2(x_5)(x_7)^2 = 0 \tag{2}$$

$$f_2(x) = x_2 - (K_{II})(x_7)(x_5) = 0 \tag{2}$$

$$f_3(x) = x_4^2 - (K_{III})^2(x_3)^2(x_5) = 0 \tag{3}$$

$$f_4(x) = x_6 - (K_{IV})(x_7)(x_3) = 0 \tag{4}$$

$$f_5(x) = x_1 + x_2 + x_3 + x_4 + x_5 + x_6 - 1 = 0 \tag{5}$$

$$f_6(x) = x_5 - A = 0 \tag{6}$$

$$f_7(x) = x_4 + x_3 + 2x_6 - B = 0 \tag{7}$$

In the above system of equations x_1, x_2, x_3, x_4, x_5, x_6 are the equilibrium mole fraction of CO, CO_2, H_2, H_2O, O_2, and CH_4, respectively, and x_7 is activity of carbon. A and B, as indicated above, are the equilibrium oxygen partial pressure, and the input hydrogen concentration, respectively.

In addition, there are seven side conditions,

$$1.0 \geq x_i \geq 0 \qquad i = 1,2,\ldots 7 \tag{8}$$

These conditions insure that all mole fractions in the equilibrium mixture are non-negative, that is, any solution of equations 1-7 that contains negative mole fractions and negative activity is thermodynamically meaningless. From physical-chemical principles, there is one and only one solution of the equations that satisfies conditions (8). Any irrelevant solutions may be therefore detected and discarded readily.

In the case of graphite, where carbon activity at all temperatures and pressures is assigned a value of unity, i.e.,

standard state of carbon, there are only six equations (equation 6 drops out) and six unknown ($x_7 = a_c = 1.00$). Hence, the effect of variation of input hydrogen content, B, on the composition of the gaseous constituents, including the equilibrium oxygen partial pressure x_5, is studied.

The system of simultaneous nonlinear equations has been solved using the Newton-Raphson method as described by Carnahan, et al.[3] The partial derivatives of equations 1-7 are obtained by partial differentiation of the seven functions, $f_i(x)$, with respect to each of the seven variables. For example,

$$\frac{\partial f_1}{\partial x_1} = 2x_1 , \qquad \frac{\partial f_1}{\partial x_7} = -2(K_I)^2(x_5)(x_7)$$

$$\frac{\partial f_2}{\partial x_2} = 1.0 , \qquad \frac{\partial f_2}{\partial x_5} = -(K_{II})(x_7)$$

$$\frac{\partial f_4}{\partial x_3} = -2(K_{IV})(x_7)(x_3), \qquad \frac{\partial f_4}{\partial x_7} = -(K_{IV})(x_3)$$

The Newton-Raphson method consists of providing the initial guess for the unknown, solving the linear system of equations, a check for possible convergence to a solution, and finally the iterative process is contained until the desired accuracy exceeds or equals some specified upper limit. The Newton-Raphson method guarantees a quadratic convergence to the real roots.

Results and Discussion

The choice of initial guess of unknowns was very critical in the efficiency of numerical computation. With a wise and

educated guess it was possible to obtain convergence (within 0.00001) to the true roots within 10 iterations. The convergence was tested by starting the computation with a different set of guesses, and in all the successful runs, the results converged to the identical set of values. Physically meaningless results were discarded.

Graphite

The results for graphite (a_C = 1.00) at one atmospheric pressure are shown in Tables 4-6. The first column of these tables lists the input hydrogen concentration and the next six columns record the equilibrium CO, CO_2, H_2, H_2O, CH_4, and oxygen partial pressures or mole fractions. The last column of Tables 4-6 list the absolute value of the electromotive force in mV of a hypothetical galvanic cell I consisting of an ideal graphite with no hydrogen contamination and a graphite with a given hydrogen contamination, as two electrodes fixing different equilibrium oxygen partial pressure.

$$\underset{p_{O_2}^{I}}{\overset{\text{Pt/Graphite}}{\text{C-O}}} \;//\; \text{S.O.E.} \;//\; \underset{p_{O_2}^{II}}{\overset{\text{Graphite/Pt}}{\text{(C-O-H)}}} \qquad [I]$$

$$E(I) = \frac{RT}{4F} \ln \left[\frac{p_{O_2}^{\ I}}{p_{O_2}^{\ II}} \right]$$

In other words, the absolute value of E is the upper bound of the error introduced in the measured thermodynamics of carbon when the

TABLE 4: Composition of gaseous constituents in equilibrium with graphite at 1073°K, 1 atm. pressure

$(p_{H_2})_i$	p_{CO}	p_{CO_2}	p_{H_2}	p_{H_2O} ($\times 10^{-2}$)	p_{CH_4} ($\times 10^{-5}$)	p_{O_2} ($\times 10^{-20}$)	$\lvert E \rvert$ (mV)
0.000	0.8750	0.1250	0.0000	0.0000	0.0000	0.7327	0.00
0.001	0.8742	0.1248	0.0009	0.0114	0.0036	0.7314	0.04
0.010	0.8672	0.1228	0.0089	0.1126	0.3626	0.7197	0.41
0.050	0.8360	0.1141	0.0444	0.5436	9.0864	0.6688	2.11
0.100	0.7967	0.1036	0.0889	1.0377	36.452	0.6074	4.33
0.200	0.7174	0.0840	0.1783	1.8744	146.68	0.4926	9.18
0.400	0.5555	0.0504	0.3589	2.9213	594.19	0.2954	21.0
0.600	0.3889	0.0247	0.5420	3.0880	1355.2	0.1447	37.5
0.800	0.2168	0.0077	0.7280	2.3121	2444.6	0.0450	64.5
0.900	0.1285	0.0027	0.8222	1.5477	3118.1	0.0158	88.7
1.000	0.0386	0.0002	0.9172	0.5182	3880.6	0.0014	144

TABLE 5: Composition of gaseous constituents in equilibrium with graphite at 1273°K, 1 atm. pressure

$(p_{H_2})_i$	p_{CO}	p_{CO_2} ($\times 10^{-2}$)	p_{H_2}	p_{H_2O} ($\times 10^{-2}$)	p_{CH_4} ($\times 10^{-3}$)	p_{O_2} ($\times 10^{-18}$)	$\lvert E \rvert$ (mV)
0.000	0.9914	0.8608	0.0000	0.0000	0.0000	0.5218	0.00
0.001	0.9904	0.8591	0.0010	0.0014	0.0000	0.5208	0.05
0.010	0.9816	0.8439	0.0099	0.0130	0.0009	0.5116	0.54
0.050	0.9422	0.7776	0.0493	0.0624	0.0223	0.4714	2.79
0.100	0.8931	0.6986	0.0986	0.1183	0.0891	0.4235	5.72
0.200	0.7948	0.5533	0.1972	0.2104	0.3561	0.3354	12.12
0.400	0.5983	0.3135	0.3940	0.3165	1.4217	0.1900	27.7
0.600	0.4018	0.1414	0.5904	0.3185	3.1927	0.0857	49.5
0.800	0.2053	0.0369	0.7865	0.2168	5.6650	0.0224	86.4
0.900	0.1071	0.0100	0.8844	0.1271	7.1635	0.0061	122
1.000	0.0088	0.0001	0.9822	0.0116	8.8836	0.00004	259

TABLE 6: Composition of gaseous constituents in equilibrium with with graphite at 1473°K, 1 atm. pressure

$(p_{H_2})_i$	p_{CO_2}	p_{CO_2} $(\times 10^{-2})$	p_{H_2}	p_{H_2O} $(\times 10^{-4})$	p_{CH_4} $(\times 10^{-6})$	p_{O_2} $(\times 10^{-17})$	$\|E\|$ (mV)
0.000	0.9990	0.1038	0.0000	0.0000	0.0000	0.9878	0.00
0.001	0.9980	0.1036	0.0010	0.0234	0.0028	0.9858	0.06
0.010	0.9890	0.1017	0.0100	0.2406	0.2807	0.9682	0.64
0.050	0.9491	0.0937	0.0499	1.1149	7.0164	0.8916	3.25
0.100	0.8992	0.0841	0.0997	2.1120	28.056	0.8003	6.68
0.200	0.7994	0.0664	0.1994	3.7542	112.15	0.6326	14.1
0.400	0.6001	0.0374	0.3985	5.6320	448.02	0.3564	32.3
0.600	0.4008	0.0167	0.5974	5.6400	1006.8	0.1590	58.0
0.800	0.2017	0.0042	0.7960	3.7826	1787.4	0.0403	102
0.900	0.1022	0.0011	0.8953	2.1559	2260.8	0.0104	145
1.000	0.0028	0.0000	0.9944	0.0982	2789.3	0.00008	373

results of hydrogen contaminated graphite (C-O-H) is approximated, as a limiting case, to the uncontaminated system (C-O). The following conclusions can be drawn from the results obtained.

(1) At all temperatures the composition of gaseous constituents in equilibrium with graphite either increase (H_2, CH_4) or decreases (CO, CO_2, O_2) monotonically, except H_2O which shows a maxima around $(p_{H_2})_i = 0.60$.

(2) The stoichiometric amount of methane is very small (almost negligible) at all temperatures and $(p_{H_2})_i$ as high as even 1.00. This checks the earlier assumption of totally negligible proportions of higher hydrocarbons.

(3) The equilibrium hydrogen concentration is almost identical to the input concentration $(p_{H_2})_i$, implying that water vapor and methane are very minor constituents of gases in equilibrium with graphite under these conditions.

(4) At lower hydrogen concentration, CO is the major constituent, and the proportion becomes even more overwhelming in favor of CO at higher temperatures.

(5) The upper bound of the experimental error is about 0.5 mV, for a graphite containing as much as 1% hydrogen, which is well within the accuracy limits of the measured emf. Rather large amounts of hydrogen (approx. 10% atomic hydrogen in solid graphite) would have to be released from the small samples used to raise the gas phase hydrogen content to 1%.

The results of Tables 4-6 along with some additional data are summarized in Figure 4. The most important portion of the

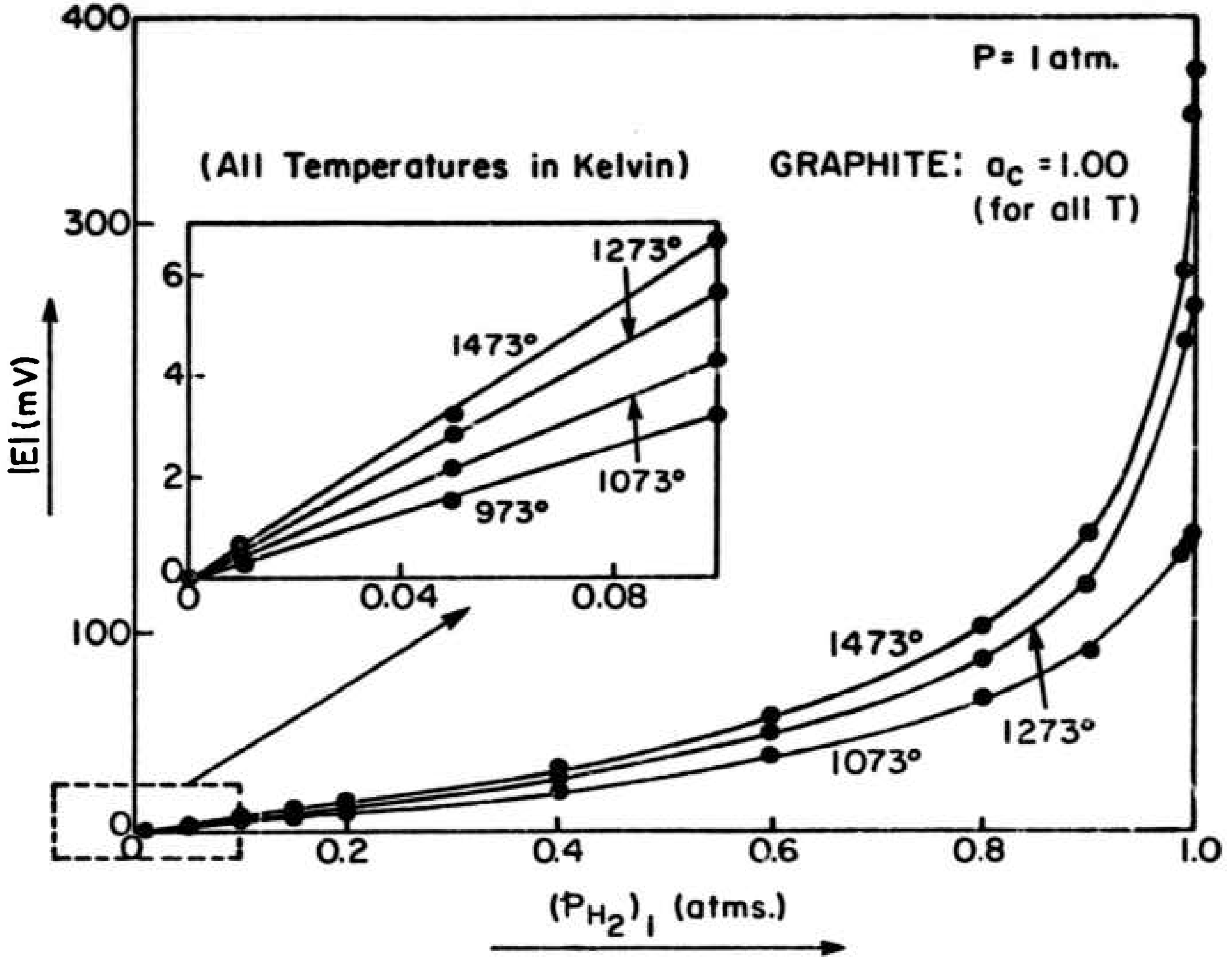

Figure 4. Effect of initial hydrogen concentration on the upper bound of the experimental error.

curves $[(p_{H_2})_i = 0 - 0.1]$ has been blown up to demonstrate the above conclusion more clearly.

Glassy Carbon

Additional computations were done on a typical glassy carbon, characterized by $\Delta H = 9,000$ cal/mole, $\Delta S = 9.00$ e.u. relative to graphite. The results have been shown in Table 7. If calculations were made on the C-O system alone, the experimentally measured value of emf of the cell against hydrogen free graphite, would be 12.50 mV at 1073°K. This corresponds to an equilibrium oxygen partial pressure of 0.1258×10^{-19} atms, is the experimentally measured value and hence appears as constant in all five rows. The calculated value of carbon activity based on $p_{O_2} = 0.1258 \times 10^{-19}$ atm. has been calculated as a function of hydrogen contamination. The value of $|E|$ is the emf in mV which would be obtained if a hypothetical cell II were operated:

$$\underset{(C\text{-}O)}{\text{Pt/Glassy Carbon}} // \text{S.O.E.} // \underset{(C\text{-}O\text{-}H)}{\text{Glassy Carbon/Pt}} \qquad \text{(II)}$$

and $|\Delta G|$ is the free energy difference between two states of glassy carbon. Therefore, $|E|$ and $|\Delta G|$ are the measure of experimental uncertainty due to hydrogen contamination. The values of $|\Delta G|$ has been directly obtained by the relation

$$|\Delta G| = RT \ln \frac{a_{C_I}}{a_{C_{II}}}$$

where a_{C_I} and $a_{C_{II}}$ are the carbon activities of the left hand

TABLE 7: Composition of gaseous constituents in equilibrium with a glassy carbon (ΔH = 9,000; ΔS = 9.0) at 1073°K, 1 atm. pressure

$(p_{H_2})_i$	p_{CO}	p_{CO_2}	p_{H_2} ($\times 10^{-3}$)	p_{H_2O} ($\times 10^{-3}$)	p_{CH_4} ($\times 10^{-7}$)	p_{O_2} ($\times 10^{-19}$)	a_C	$\lvert E \rvert$ (mV)	$\lvert \Delta G \rvert$ (cal./mole)
0.000	0.8423	0.1577	0.0000	0.0000	0.0000	0.1258	0.7348	0.00	0
0.001	0.8414	0.1575	0.8561	0.1438	0.2481	0.1258	0.7338	0.04	3.0
0.010	0.8339	0.1561	8.5574	1.4377	24.565	0.1258	0.7272	0.36	22
0.050	0.8002	0.1498	42.7077	7.1749	587.17	0.1258	0.6979	2.04	110
0.100	0.7582	0.1420	85.237	14.320	2216.2	0.1258	0.6613	4.20	225

and right hand electrodes respectively. The value of $|E|$ is the difference between 12.50 mV (emf of the uncontaminated hydrogen cell) and the value of emf obtained from the quadratic equation:

$$a_{c_{II}} = [(Y)(X)(Z)\ \{1 + (Y)(X)\}]^{-1}$$

where

$Y = (p_{CO_2}/p_{CO})$ of uncontaminated graphite

$X = e^{2EF/RT}$

Z = equilibrium constant of the producer gas reaction ($C_{GR} + CO_2 = 2CO$)

$a_{c_{II}}$ = Carbon activity in the hydrogen containing glassy carbon.

The following conclusions are drawn:

(1) The carbon activity of glassy carbon in hydrogen contaminated atmosphere is lower than the same structured carbon without hydrogen present.

(2) The effect of 1% gas phase hydrogen contamination does not change the experimental results beyond the accuracy limits of about 0.5 mV and 25 cal/mole. If all the hydrogen structurally associated with solid glassy carbon samples (1/4" × 1/8") were to be released, 1% gas phase hydrogen contamination corresponds to roughly 10% atomic hydrogen content of the solid carbon. Hence, the hydrogen content from solid carbon alone does not significantly affect the thermodynamic calculations approximated by C-O binary.

Therefore, it is concluded that the presence of any possible hydrogen in solid carbon could not have possibly accounted for the large measured free energy differences between graphite and glassy carbon.

C. Small Angle X-ray Diffraction

Small angle X-ray scattering is being used to study microporosity of selected glassy carbon samples. Recent theoretical developments in the small angle X-ray analysis allow the determination of general structural parameters of both matter and the pore phases. Determination of the pore size, pore shape, distribution of pore sizes, internal surface area, etc., is possible if a detailed analysis is carried out[1,9].

Experimental Procedure

Use of the Rigaku-Denki small angle unit equipped with a proportional counter, automatic step-scanner and digital printout is being used to measure the scattered intensity. Previously, slit collimation together with point focusing was used instead of line focusing. This resulted in a larger penalty in intensity. The point focus gave a smaller variation in the primary beam intensity with time, but increased the experimental time due to low intensity.

Recently Kratky[4,5] has described a collimation method using line focus not only to obtain maximum primary beam intensity but also to minimize effects of variation in room temperature, vibrations, and drifting of the focus. This "opening-beam" method requires that the tube window opening be slightly larger than the focal length. Since both of these parameters depend upon the tube and cannot be changed, generally it is not possible to achieve the opening-beam geometry. Fortunately a fine focus tube is

available with an 8 mm. focus and 10 mm. window. However the filter-mounting plate, collimator mounts, etc., has an opening less than 8 mm. and therefore some modifications in the Rigaku-Denki unit were made to achieve the described collimation.

The above collimation system was able to increase the primary beam intensity by about 10 times compared to the point focus geometry. This reduced the experimental time to about 40 minutes from 3-4 hours with a resultant increased counting accuracy.

Filtered Cu-Kα radiation is used in conjunction with a pulse-height discriminator. As pointed out by Kratky[4,5] use of a narrow channel width discriminator results in radiation sufficiently monochromatic for all but extremely rigorous work. The tube is being operated at 54 KV and 25 mA.

Correction of Observed-Intensity

Weighting-Function

When using slit-collimation the observed scattering is not at a single angle but represents the average scattering over a range of angles around the nominal scattering. The range of angles is often so large that the scattering pattern is distorted. Therefore experimental scattering data must be corrected for this effect.

The extent of the angular region over which the collimation system averages the scattering and the relative emphasis given to angles within this range can be conveniently expressed

by a weighting function. The weighting function in the width direction of the slits can be experimentally measured as this is the shape of the direct beam. However it is generally not possible to measure the weighting function in the length or height direction, and therefore it is to calculate W_ℓ from the known collimation geometry.

The calculation of the length and width weighting function was made by a computer program written by Hendricks and Schmidt[6]. Only minor changes were made in this program. The width weighting function, Ww, was very small compared to W_ℓ, and therefore width corrections were dropped after noticing no change in the width corrected curve and the observed curve.

However W_ℓ or Ww cannot be calculated very easily and accurately if the soller-slits are used in the detector slit box. Since the soller slits were used previously there is no easy way to get corrected curves from the samples reported earlier.

<u>Correction Program</u>

Scattering intensity, F(s) is related to perfect-collimation scattering I(s) by the equation,

$$F(s) = \int_{-\infty}^{\infty} W(Z)I\ (\sqrt{S^2+Z^2})\ dZ \tag{1}$$

where $S = (2\theta/\lambda)$ and W(Z) is W_ℓ the length weighting function is normalized so that

$$\int_{-\infty}^{\infty} W(Z)\ dZ = 1$$

Integration in (1) is needed only in +Z direction, since W(Z) is an even function of Z, therefore,

$$F(s) = 2 \int_{-0}^{\infty} W(Z) I \left(\sqrt{S^2+Z^2}\right) dZ \qquad (2)$$

Equation 2 is used to calculate I(s). The procedure requires a process of deconvolution. Two programs are available to carry out the deconvolution or desmearing. However only Schmidt's[7] program was able to give corrected curves. The other program, written by Lake[8] did not work since it did not converge even after 10 iterations.

The method developed by Schmidt requires that W(Z) be Gaussian, that is,

$$W(Z) = 2W(0)\exp(-p^2Z^2) \qquad (3)$$

hence

$$\int_{0}^{\infty} 2W(0)\exp(-p^2Z^2)\, dZ = 1$$

from which $p = W(0) \cdot \sqrt{\pi}$ can be obtained.

In our case the weighting function was Gaussian and could be written as

$$W(Z) = (0.01658) \times 2 \exp(-p^2Z^2)$$

with p = 0.02855.

The parameter "p" is all that is needed to correct the observed curve.

A difficulty was observed in many samples, particularly those with very low radius of gyration, was that ripples were caused by even slight scatter in the data even though Schmidt claims otherwise. For those samples it was necessary to develop a program to smooth the data before correction. A program has been developed to do this smoothing.

Results

Various samples have been analyzed by both Guinier and Porod plots.

For the evaluation of R_G, the Guinier radius, the approximation

$$I(S) = n^2 \exp(-\frac{4}{3}\pi^2 R_G{}^2 S^2)$$

is considered to be valid. Here I(S) is the corrected observed intensity and S is 2 sinθ/λ where θ and λ are the Bragg angle and wavelength, respectively. The R_G can be obtained from the plot of I(S) versus S^2, which is a straight line if the distribution of pore size is very narrow. However if a wide range of pore sizes are present then the plot is no longer linear but curved concave upward, i.e., intensity increases sharply at lower S^2.

Pore size is directly related to the R_G and can be calculated if the shape of the pores is known. If the pores are spherical then

$$a = \sqrt{\frac{5}{3}}\, R_G$$

where a is the radius of the pore.

Porod's plot (log I(S) versus log S) has been shown to be linear over wide range of S values if the density transitions between the phases are sharp as would be the case of pores within the carbon.

For all the commercial samples thus far studied in this laboratory or reported in the literature, Guinier's law is followed, that is, the log I versus S^2 plots are a straight line from very low S^2 value to high S^2 value ($\sim 1.5\times 10^{-4}\text{Å}^2$). For the samples studied in our laboratory, given in Table 8, this has been verified. The Guinier radius, R_G, is in excellent agreement with the published data. All the samples are found to be monodisperse, that is pore size for a particular sample is almost constant.

For the samples made at the University of Michigan, many more samples are polydisperse than monodisperse. Very few samples follow Guinier law over wide ranges of S^2 values as in the commercial samples. Only size out of twenty-four samples for which corrected R_G values are reported in Table 9 follow Guinier law giving a single value of pore size. These samples are 317-26, 317-45, 318-5A, 318-7, 318-11, 318-51 all heat treated at 2000°C. Even these samples show a rapid increase in intensity near very low S values ($<0.2\times 10^{-4}\text{Å}^2$).

However, the Guinier plots of the most of the polydisperse samples have a straight line portion in higher S^2 values (~ 1.5-$3\times 10^{-4}\text{Å}^{-2}$). From the slope of this straight line a lower value of R_G can be calculated. These R_G values were found to be $\sim$10-16Å for samples with HTT of 2000°C and $\sim$5Å for samples of HTT

Table 8. Corrected R_G for Commercial Samples

Sample	Our Value R_G (Å)	Reported Value (R_G Å)	Dispersity
LMSC-20	14.8	13.2	Monodisperse
LMSC-26	12.6	----	Monodisperse
LMSC-30	26.0	23.4	Monodisperse
GC-10	5.2	5.7	Monodisperse
GC-20	9.2	9.5	Monodisperse
V-25	13.9	15.5	Monodisperse
Beckwith-20	10.8	----	Monodisperse
V-10-42	14.8	----	Monodisperse
PFA-2000	13.1	13.0	Monodisperse

TABLE 9: Composition of gaseous constituents in equilibrium with graphite at 1073°K, 1 atm. pressure

$(p_{H_2})_i$	p_{CO}	p_{CO_2}	p_{H_2}	p_{H_2O} $(\times 10^{-2})$	p_{CH_4} $(\times 10^{-5})$	p_{O_2} $(\times 10^{-20})$	$\lvert E \rvert$ (mV)
0.000	0.8750	0.1250	0.0000	0.0000	0.0000	0.7327	0.00
0.001	0.8742	0.1248	0.0009	0.0114	0.0036	0.7314	0.04
0.010	0.8672	0.1228	0.0089	0.1126	0.3626	0.7197	0.41
0.050	0.8360	0.1141	0.0444	0.5436	9.0864	0.6688	2.11
0.100	0.7967	0.1036	0.0889	1.0377	36.452	0.6074	4.33
0.200	0.7174	0.0840	0.1783	1.8744	146.68	0.4926	9.18
0.400	0.5555	0.0504	0.3589	2.9213	594.19	0.2954	21.0
0.600	0.3889	0.0247	0.5420	3.0880	1355.2	0.1447	37.5
0.800	0.2168	0.0077	0.7280	2.3121	2444.6	0.0450	64.5
0.900	0.1285	0.0027	0.8222	1.5477	3118.1	0.0158	88.7
1.000	0.0386	0.0002	0.9172	0.5182	3880.6	0.0014	144

of 700°C. These values are approximately the same as the R_G values of typical monodisperse samples at these temperatures. At present no relationship between any processing variable and whether or not the sample is polydisperse can be identified.

To calculate the range of R_G values, the method of Jellinek, Solomon and Fankuchen[9] was used. In this method a tangent is drawn to the Guinier plot at the greatest angle of scattering and the lowest R_G is calculated from the slope of this line. The intensity values corresponding to this tangent are next subtracted from the original curve to give a curve not containing the contribution of the pores below this R_G. The method is repeated until the whole curve is covered.

In our case the above analysis gave very interesting results. The first tangent in all the cases was the same as the straight line portion of the Guinier plots. Once the intensity contribution of this was subtracted the remaining curve could be approximated by another straight line. The slope of these straight lines then was used to get the highest R_G contributing to the scattering. These R_G values were found to be in the range of 50-90 Å for all the samples.

Thus we can say that the polydisperse samples contain a significant fraction of pores of R_G in the range 50-90 Å giving a sharp rise in intensity over lower angles. Some commercial samples have shown similar behavior as reported by Ruland and Perret[10], however the fraction of pores in this size range was

too small to cause any significant change in the Guinier plot. Further analysis is being carried out to determine the distribution of pores over the range discernible from the Guinier plot. This data then will be correlated with the porosimetry data.

The above results show that some of our samples contain a greater fraction of pores of larger size than the commercial samples. These contain a much greater porosity than the commercial samples. For example 312-31 (2000), 318-22 (2000) and 318-45 (2000) for which porosimetry data are available show that a significant fraction of pores is present with diameters of 40 to 200 Å (roughly corresponding R_G values of 15-75 Å if spherical shape is assumed). However, porosimetry data on the six samples which show monodispersity are not available to strengthen this point.

A method is being developed to obtain the weight and number fraction of the pores in a given size group. Then the samples for which porosimetry data are available will be correlated with the small angle data.

The scanning electron micrographs are available on some of the samples studied. However, the resolution of these micrographs is limited to ∿200 Å and therefore is of no direct use for comparison.

Micrographs of samples 317-26 (2000), 317-45 (2000), 318-51 (2000) show only very coarse voids and it is very difficult to see any voids of diameter below 500 Å. This agrees well

with the small angle study of these samples which shows them to be monodisperse and that they have only an extremely small fraction of voids in the range 150-500 Å. However sample 318-11 (2000) which is found to be monodisperse from small angle X-ray analysis shows that some voids are present in the range 200-400 Å size as seen in the electron scanning micrograph (50,000 X). However, the fraction of visible pores below 400 Å seems to be small.

For the polydisperse samples 317-45 (700), 318-12 (2000), 318-46 (2000) and 318-48 (2000) for which the scanning micrographs are available it is very hard to make any general conclusion because of lack of resolution. However it is certain that these samples have some visible voids of diameter 200-500 Å. Sample 318-46 (2000) shows a large number of voids present in the range 150-400 Å and the small angle analysis shows that the sample is polydisperse with most voids in the range 50-150 Å. Thus, there is qualitative agreement between these two techniques.

The Porod plots for the above samples have been analyzed. For the commercial samples, plots from the corrected data are very similar to those reported earlier[1] and published in the literature. The curves contain a flat region followed by a straight line portion at higher S values. This indicates the density transition from pore to carbon is very sharp.

The Porod plots for samples made at the University of Michigan are similar to those reported earlier[1]. The region

at lower S values is not as flat as in commercial samples that are polydisperse (see Table 9) the flat region is barely present. However straight line behavior is found in all the samples over a wide range of S values. This indicates that the density transition is very sharp.

Sample 312-31 (2000) has been studied using neutron time-of-flight diffraction method by Mildner[11]. He found a characteristic void dimension of 13.6 Å. However, he did not study the sample in the S range in which the Guinier law is obeyed for particles of R_G = 14.2 Å, the value found by X-ray. However, at higher S values he does support our finding that Porod's law is obeyed.

Table 9. Corrected R_G for Samples Made at University of Michigan.

Sample	R_G (Å)	Polydispersity
311-19 (750)	5 - 65	Polydisperse
312-10 (2000)	19.7 - 53	Polydisperse
312-31 (2000)	14.2 - 65	Polydisperse
315-22 (2000)	12.0 - 70	Polydisperse
317-24 (2000)	10.2 - 70	
317-26 (2000)	15.6	Monodisperse
317-45 (700)	4.0 - 90	Polydisperse
317-45 (2000)	14.8	Monodisperse
317-48 (700)	5 - 85	Polydisperse
317-48 (2000)	10.5 - 66	Polydisperse
318-5A (2000)	16.4	Monodisperse
-7 (2000)	16.3	Monodisperse
-8 (2000)	14.2 - 63	Polydisperse
-9 (2000)	15.8 - 75	Polydisperse
-11 (2000)	13.2	Monodisperse
-12 (2000)	15.7 - 75	Polydisperse
-22 (2000)	15.0 - 68	Polydisperse
-23 (2000)	14.0 - 60	Polydisperse
-41 (2000)	15.8 - 61	Polydisperse
-45 (2000)	20.4 - 53	Polydisperse
-46 (2000)	14.0 - 40	Polydisperse
-48 (2000)	10.0 - 66	Polydisperse
-49 (2000)	10.0 - 67	Polydisperse
-51 (2000)	12.9	Monodisperse

IV. Property Evaluation

During this report period work has concentrated on measurements of strength, density and electrical resistivity. Determinations of sonic modulus, hardness, and internal friction were suspended since no clear-cut correlations could be found between these properties and structure.

Previous work[1] has shown a rough correlation between the apparent density and the strength properties; and an inverse relation between strength and average pore size. However, in both cases considerable scatter is present suggesting that significant variations in strength are caused by short range differences in carbon structure as well as the macro void structure. This point is best observed by comparing the strength and other properties on a reduced basis (see Appendix Table 10), i.e., correcting the cross-section to reflect only the area fraction carbon, ρ_a/ρ_x, present. The large variation in the reduced data, especially for electrical resistivity indicates considerable variation in carbon structure.

Other correlations with properties with such variables as real density (xylene) or X-ray parameters have not been able to significantly reduce the variation observed between different carbons. At present the strongest correlation found is between the reduced compressive strength and the reduced electrical resistivity. The strength data have been separated into five ranges and the reduced resistivity averaged for each group.

The results shown below give a definite inverse relationship with resistivity.

Reduced Compressive Strength, psi	Reduced Electrical Resistivity, Ω-cm
44,000 and up	.0088
20,000-43,000	.0112
15,000-20,000	.0133
10,000-15,000	.0153
1,000-10,000	.0220

Since lower resistivity would be expected to result from better perfection and lower strain within the layer structure, these results strongly suggest that higher strength also is favored by more perfect layers. This is not surprising, since the graphite layer structure is the strongest material known parallel to the layers.

The inability to get clear-cut correlations of the properties with the more usual structural parameters suggests that other measures such as the thermodynamic order parameters, ΔH and ΔS, or the very fine scale void structure as determined by small angle X-ray might provide an answer. The differences might well be related to variations in the polydisperse very fine pore spectrum noted in the small angle X-ray experiments.

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APPENDIX

TABLE 1 SUMMARY OF X-RAY DATA

(All values in Angstroms)

Symbols Used in the Tables

Experimental Condition

All the samples were run in a Phillips-Norelco Diffractometer using CuKα radiation under the following conditions:

Tube Voltage: 45KV
Tube Current: 14mA
Proportional Counter Voltage: 1.622KV
Proportional Counter Time Constant: 4 sec.
Chart Speed: 1/2 inch/min.
Scan Speed: 1.2 degree (2θ)/min.
Slits: 1°/006"/1° at Primary/Scattering/Secondary

Sample used of thickness of 3mm in all cases except where otherwise designated. The value of d(10) refers to the unresolved (100) and (101) peak.

(002) Peak Type

S: "Smooth" (or single phase) Peak
NVS: "Not Very Smooth" Peak
2P: "2 Phase" Peak
3P: "3 Phase" Peak

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
Graphite, solid 3mm & 1mm thick		S	3.37	Very High	2.13	Very High
Graphite		S	3.37	Very High	2.13	Very High
Graphite, natural (Reported)		S	3.35	Very High	2.13	Very High
Graphite, synthetic (Reported)		S	3.37	Very High	2.13	Very High

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
Commercial Samples						
Lockheed, solid	2000	S	3.53	21.2	2.09	98.0
Lockheed, reported	2000		3.56	19.0	--	--
Beckwith, solid	2000	S	3.55	23.2	2.09	112.0
Beckwith, reported	2000		3.54	15.0	--	50.0
Tokai, solid	1000	S	3.70	14.2	2.07	43.7
Tokai, reported	2000		--	--	--	--
Atomergic Chemicals Co., V-25, solid	2500	S	3.40	38.4	2.09	69.0
Atomergic Chemicals Co., V-25, reported	2500					
Atomergic Chemicals Co., V-10	1000	NVS	3.44	42.0	2.10	71.0
Atomergic Chemicals Co., V-10, reported	1000		--	--	--	--
Hercules H-54	1795	S	3.49	28.0	2.09	51.0
311-9	2000	S	3.54	28.0	2.10	57.0
311-19	700	S	3.63	18.0	--	--
311-20	2000	S	3.53	27.2	2.10	46.0
311-21	2000	S	3.52	27.2	2.10	54.0
311-22	2000	2P	2.49 3.45	29.0	2.12	>125.0
311-25	700	S	3.70	21.0	--	--
311-30A	2000	S	3.51	23.4	2.10	54.0
311-31	2000	S	3.50	25.0	2.10	51.0
312-8	2000	S	3.52	27.0	2.10	42.0
312-9	2000	2P	3.52 3.45	27.0	2.10	57.0
312-10	700	S	3.65	16.2	--	--
312-10	2000	S	3.49	35.0	2.11	53.0
312-14	2000	S	3.51	29.0	2.09	61.0
312-14A	2000	3P	3.46 3.43 3.36	32.0	2.12	>150.0
312-15	2000	S	3.52	27.1	2.11	51.0
312-16	2000	3P	3.47 3.43 3.36	32.1	2.11	51.0
312-21	2000	S	3.51	30.8	2.10	57.0
312-26	2000	S	3.51	27.8	2.09	48.0
312-28	2000	S	3.51	27.2	2.10	51.0
312-29	2000	S	3.51	34.0	2.10	57.0
312-31, solid	2000	S	3.57	27.6	2.10	56.0
312-32	2000	S	3.51	30.8	2.10	54.0
312-33	2000	NVS	3.48	30.8	2.10	52.8

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
312-34	2000	2P	3.46	33.0	2.11	46.2
			3.44			
312-39	2000	S	3.49	29.8	2.10	53.0
312-40	2000	2P	3.48	30.1	2.09	54.0
			3.45			
312-43	2000	2P	3.48	33.2	2.11	51.0
			3.43			
312-44	2000	2P	3.48	42.0	2.11	51.0
			3.44			
312-48	2000	3P	3.46	30.4	2.10	37.0
			3.43			
			3.37			
312-49	2000	S	3.52	31.1	2.11	61.0
315-1	2000	S	3.53	27.2	2.10	48.0
315-2	2000	2P	3.49	29.0	2.10	54.0
			3.43			
315-3	700	S	3.71	16.2	--	--
315-5	2000	2P	3.49	29.0	2.11	54.0
			3.44			
315-8	2000	2P	3.49	28.2	2.10	56.0
			3.44			
315-9	2000	2P	3.47	33.0	2.11	47.0
			3.44			
315-14	2000	S	3.53	26.3	2.10	54.0
315-18	2000	3P	3.40	45.0	--	--
			3.382			
			3.351			
315-20	680	S	3.70	16.3	--	--
315-20A	2000	2P	3.53	28.0	2.10	57.0
			3.43			
315-21C	2000	2P	3.52	27.8	2.10	57.0
			3.43			
315-22	665	S	3.67	16.4	--	--
315-22	2000	S	3.52	28.0	2.10	51.0
315-24A	2000	2P	3.47	20.0	--	--
			3.38			
315-25A	2000	S	3.52	26.5	2.09	48.0
315-26B	2000	3P	3.50	26.5	2.10	46.0
			3.41			
			3.37			
315-26C	680	S	3.69	17.1	--	--
315-28	2000	2P	3.52	26.0	2.10	46.0
			3.43			
315-28B	600	S	3.70	16.8	--	--
315-30	2000	2P	3.56	24.0	2.09	48.0
			3.43			
315-31	680	S	3.70	18.2	--	--
315-34	680	S	3.69	15.4	--	--

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
315-36	2000	3P	3.52	24.3	2.10	48.5
			3.43			
			3.37			
315-37	680	S	3.63	17.5	--	--
315-37	2000	S	3.50	26.3	2.098	42.0
315-38	680	S	3.63	18.8	--	--
315-38	2000	2P	3.49	27.1	2.097	46.0
			3.43			
315-39	2000	2P	3.53	27.2	2.098	57.0
			3.43			
315-39	680	S	3.63	20.0	--	--
315-40	2000	S	3.54	25.6	2.097	51.0
315-41	2000	NVS	3.49	23.6	2.098	51.0
315-42	2000	S	3.56	27.2	2.098	46.0
315-43	2000	NVS	3.52	24.3	2.098	51.0
315-43	700	S	3.67	17.4	--	--
315-44	2000	2P	3.55	23.1	2.10	40.2
			3.45			
315-45	2000	S	3.49	27.2	2.10	46.6
315-46A	2000	2P	3.55	23.1	2.098	57.0
			3.43			
316-6	2000	NVS	3.50	27.0	2.11	57.0
316-7, Run 1	2000	S	3.49	28.0	2.10	45.0
316-7, Run 2	2000	S	3.52	27.0	2.10	53.0
316-15	2000	2P	3.40	32.0	--	--
316-28	2000	S	3.50	27.2	2.10	51.0
316-32	2000	2P	3.42	53.0	--	--
			3.40			
317-1	700	S	3.71	20.0	--	--
317-1	2000	S	3.46	45.0	2.11	63.0
317-2	700	S	3.68	15.7	--	--
317-2	2000	NVS	3.48	24.6	2.09	47.0
317-6	700	S	3.71	13.0	--	--
317-6	2000	NVS	3.55	22.0	2.10	55.0
317-7	700	S	3.68	16.0	--	--
317-7	2000	NVS	3.46	27.5	2.10	50.0
317-8	700	S	3.71	11.5	--	--
317-8	2000	2P	3.56	20.0	2.10	44.0
			3.46			
317-10	2000	NVS	3.48	26.0	2.10	68.0
317-11	700	S	3.71	16.3	--	--
317-13	700	S	3.72	15.0	--	--
317-13	2000	NVS	3.47	24.0	2.08	66.0
317-14	700	S	3.71	15.7	--	--
317-14	2000	NVS	3.45	27.0	2.09	46.0
317-15	700	S	3.71	15.3	--	--
317-15	2000	NVS	3.47	26.0	2.09	54.0
317-15	2000	S	3.54	24.0	2.09	53.0

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
317-18	2000	S	3.59	21.0	2.09	58.0
317-19	700	S	3.68	16.5	--	--
317-19	2000	NVS	3.49	30.0	2.09	52.0
317-20	700	S	3.66	17.5	--	--
317-20	2000	S	3.50	25.6	2.09	48.0
317-24, Run 1	2000	NVS	3.52	24.0	2.09	45.0
317-24, Run 2, solid	2000	NVS	3.49	21.0	2.09	50.0
317-25	2000	S	3.53	20.0	2.09	50.0
317-26, Run 1	2000	NVS	3.48	26.0	2.09	48.0
317-26, Run 2, solid	2000	2P	3.46 3.43	24.2	2.10	51.0
317-28	2000	NVS	3.46	25.0	2.09	52.0
317-29	700	2P	3.43 3.32	21.5	--	--
317-29, Run 1	2000	NVS	3.43	65.0	--	--
317-29, Run 2	2000	NVS	3.426	75.0	--	--
317-30	2000	2P	3.44 3.40	29.5	--	--
317-31A	2000	S	3.58	22.0	2.10	46.0
317-32	700	S	--	--	--	--
317-32	2000	2P	3.51 3.48	23.6	2.08	49.0
317-33	700	S	3.68	17.0	--	--
317-33	2000	S	3.414	92.0	2.10	49.0
317-34	700	S	3.68	17.0	--	--
317-34	2000	3P	3.44 3.42 3.36	30.0	2.09	50.0
317-35	700	S	3.71	16.0	--	--
317-35	2000	3P	3.50 3.43 3.36	26.5	2.10	62.0
317-37	700	S	3.68	15.6	--	--
317-37	2000	NVS	3.43	43.0	2.10	63.0
317-38	700	S	3.68	15.6	--	--
317-38	2000	3P	3.54 3.43 3.37	25.0	2.09	51.0
317-39, Run 1	2000	3P	3.45 3.43 3.36	28.0	2.10	52.0
317-39, Run 2, solid, 1mm thick	2000	3P	3.52 3.42 3.37	24.2	2.09	45.0
317-39, Run 3, solid, 1mm thick	2000	3P	3.52 3.41 3.37	23.5	2.09	49.0

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
317-40	2000	3P	3.49 3.42 3.36	24.8	2.10	48.0
317-41A	2000	S	3.53	26.5	2.10	48.0
317-41B	2000	S	3.53	28.0	2.10	54.0
317-42	2000	3P	3.49 3.42 3.36	26.0	2.10	42.6
317-43	2000	3P	3.45 3.42 3.35	26.0	2.09	56.0
317-44	2000	3P	3.48 3.42 3.36	30.0	2.09	55.0
317-45, solid, 1mm thick	700	S	3.75	12.9	--	--
317-45, Run 1	2000	3P	3.48 3.40 3.35	25.0	2.09	60.0
317-45, Run 2	2000	3P	3.46 3.42 3.35	24.0	2.09	42.0
317-46	2000	3P	3.43 3.42 3.36	31.5	2.10	75.0
317-47	2000	3P	3.50 3.42 3.36	27.0	2.10	60.0
317-48, Run 1	700	S	3.71	16.2	--	--
317-48, Run 2	700	S	3.87	17.4	--	--
317-48, Run 1	2000	3P	3.45 3.43 3.37	40.0	2.10	60.0
317-48, Run 2 solid, 1mm thick	2000	3P	3.46 3.43 3.37	34.0	2.10	59.0
317-49	700	S	3.71	15.7	--	--
317-49, Run 1	2000	3P	3.49 3.41 3.35	29.0	2.09	62.0
317-49, Run 2 solid, 1mm thick	2000	3P	3.46 3.44 3.37	33.0	2.09	60.0
317-50	700	S	3.67	15.6	--	--
318-1	2000	S	3.55	28.0	2.10	54.0
318-2	2000	S	3.51	27.0	2.10	55.0
318-3, Run 1	700	S	3.70	16.7	--	--
318-3, Run 2	700	S	3.69	16.7	--	--

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
318-3	2000	2P	3.46	26.0	2.11	51.0
			3.41			
318-4	700	S	3.66	16.8	--	--
318-6A	2000	S	3.50	31.0	2.09	59.0
318-7, Run 1	2000	S	3.50	28.0	2.10	65.0
318-7, Run 2, solid	2000	S	3.49	28.0	2.10	45.0
318-8, Run 1	2000	S	3.45	39.0	2.10	63.0
318-8, Run 2 solid, 2mm thick	2000	S	3.45	43.5	2.10	77.0
318-9	2000	2P	3.48	32.5	2.11	57.0
			3.46			
318-10	520	S	3.74	15.2	--	--
318-10	2000	S	3.49	33.8	2.12	50.0
318-11, Run 1	2000	NVS	3.42	77.0	2.10	38.0
318-11, Run 2	2000	NVS	3.43	78.0	2.11	40.0
318-12	2000	3P	3.49	31.4	2.09	59.0
			3.43			
			3.36			
318-13	2000	NVS	3.42	44.0	2.10	58.0
318-14	700	S	3.65	16.0	--	--
318-14	2000	3P	3.48	30.5	2.10	60.0
			3.43			
			3.36			
318-15, Run 1	700	S	3.75	16.0	--	--
318-15, Run 2	700	S	3.75	15.1	--	--
318-15	2000	3P	3.45	30.2	2.10	60.0
			3.42			
			3.37			
318-16	700	S	3.72	15.7	--	--
318-16	2000	2P	3.43	39.0	2.09	49.0
			3.41			
318-17	700	S	3.68	16.7	--	--
318-17	2000	NVS	3.45	42.0	2.11	59.0
318-18, Run 1	700	S	3.68	16.4	--	--
318-18, Run 2	700	S	3.71	16.3	--	--
318-18	2000	S	3.55	25.6	2.10	44.0
318-19	2000	S	3.52	26.0	2.09	59.0
318-20	700	S	3.67	16.0	--	--
318-20	2000	S	3.53	21.0	2.09	48.0
318-21, Run 1	700	S	3.78	14.0	--	--
318-21, Run 2	700	S	3.75	15.4	--	--
318-21	2000	S	3.55	23.6	2.10	55.0
318-22	700	S	3.70	15.4	--	--
318-22, Run 1	2000	NVS	3.44	65.0	2.10	55.0
318-22, Run 2	2000	NVS	3.44	64.0	2.11	54.0
318-23	700	S	3.74	16.0	--	--
318-23	2000	S	3.63	63.0	2.10	73.0
318-24	700	S	3.64	16.7	--	--

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
318-24	2000	S	3.44	45.0	2.10	68.0
318-26, Run 1	700	S	3.69	15.7	--	--
318-26, Run 2	700	S	3.75	16.1	--	--
318-26, Run 3	700	S	3.69	16.7	--	--
318-27	2000	2P	3.45	35.4	2.10	47.0
			3.41			
318-28	700	S	3.75	18.0	--	--
318-28	2000	2P	3.47	27.0	--	--
			3.42			
318-29, Run 1	2000	NVS	3.45	30.0	2.08	62.0
318-29, Run 2, solid, 1mm thick	2000	2P	3.50	30.5	2.10	65.0
			3.44			
318-29, Run 3	2000	2P	3.52	31.0	2.10	60.0
			3.42			
318-30	700	S	3.64	15.2	--	--
318-30, Run 1	2000	2P	3.48	34.1	2.11	69.0
			3.43			
318-30, Run 2	2000	3P	3.45	31.0	2.11	63.0
			3.41			
			3.36			
318-31, Run 1	2000	2P	3.45	35.5	2.10	64.0
			3.43			
318-31, Run 2	2000	3P	3.47	31.0	2.11	63.0
			3.41			
			3.36			
318-32, Run 1	700	S	3.64	15.7	--	--
318-32, Run 2	700	S	3.63	16.0	--	--
318-32	2000	S	3.44	47.0	2.10	65.0
318-33	700	S	3.66	16.7	--	--
318-33	2000	NVS	3.46	28.0	2.11	64.0
318-34	700	S	3.63	16.5	--	--
318-34	2000	3P	3.49	37.0	2.10	59.0
			3.43			
			3.36			
318-35	700	S	3.71	15.3	--	--
318-35	2000	3P	3.50	34.0	2.11	67.0
			3.44			
			3.37			
318-36	700	S	3.68	17.0	--	--
318-36	2000	2P	3.51	28.0	2.10	49.0
			3.44			
318-37	700	S	3.71	16.1	--	--
318-37	2000	3P	3.46	33.6	2.10	52.0
			3.43			
			3.376			
318-38	700	S	3.71	15.6	--	--
318-38	2000	3P	3.47	28.0	2.10	49.0
			3.43			
			3.37			

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
318-39, Run 1	700	S	3.71	17.0	--	--
318-39, Run 2 solid, 1mm thick	700	S	3.65	17.2	--	--
318-39	2000	S	3.51	26.1	2.09	60.0
318-40	700	S	3.71	15.0	--	--
318-40	2000	2P	3.52 3.45	28.0	2.11	54.0
318-41	700	S	3.71	14.8	--	--
318-41	2000	S	3.50	28.0	2.09	57.0
318-43, Run 1	700	S	3.69	17.0	--	--
318-43, Run 2 solid, 1mm thick	700	S	3.71	13.8	--	--
318-43, solid	2000	S	3.44	31.0	2.12	58.0
318-44	700	S	3.72	15.6	--	--
318-44	2000	S	3.55	27.2	2.10	44.0
318-45	700	S	3.71	15.7	--	--
318-45	2000	S	3.56	25.4	2.10	46.0
318-46	700	S	3.71	15.9	--	--
318-46, solid 1mm thick	2000	S	3.53	26.2	2.11	51.0
318-47	700	S	3.71	15.0	--	--
318-47	2000	NVS	3.49	29.0	2.10	48.0
318-48, Run 1	2000	S	3.53	26.8	2.10	54.0
318-48, Run 2	2000	S	3.52	29.2	2.10	42.0
318-50, Run 1	700	S	3.71	14.3	--	--
318-50, Run 2	700	S	3.71	15.5	--	--
318-50	2000	S	3.53	26.0	2.10	46.0
318-51	2000	S	3.56	27.2	2.10	56.0
318-52	2000	S	3.53	26.5	2.10	54.0
318-53, Run 1	2000	S	3.52	26.5	2.10	54.0
318-53, Run 2	2000	S	3.54	30.0	2.10	60.0
318-54	700	S	3.66	17.0	--	--
318-55	700	S	3.71	15.2	--	--
318-56	2000	S	3.54	27.0	2.10	54.0
318-58	700	S	3.71	18.0	--	--
318-58	2000	NVS	3.51	28.2	2.10	51.0
318-59	700	S	3.68	16.7	--	--
318-59	2000	S	3.51	26.0	--	--
318-60	700	S	3.70	15.7	--	--
318-60	2000	2P	3.47 3.44	32.0	--	--
318-61	700	S	3.71	18.6	--	--
318-61	2000	S	3.52	23.3	2.09	55.0
318-62	700	S	3.70	15.3	--	--
318-62	2000	S	3.56	22.5	2.10	51.0
321-1	700	S	3.66	5.0	--	--
321-2	700	2P	3.63 3.57	17.4	--	--

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
321-2	2000	3P	3.54	22.8	2.10	51.5
			3.43			
			3.38			
321-3	700	S	3.64	17.4	--	--
321-3	2000	S	3.53	24.3	2.10	51.0
321-4	700	S	3.64	17.2	--	--
321-4	2000	-	--	--	--	--
321-5	700	S	3.63	15.4	--	--
321-5	2000	S	3.49	26.4	2.09	53.7
321-6	700	S	3.64	17.0	--	--
321-6	2000	S	3.54	27.7	2.10	48.0
321-7	700	S	3.69	18.0	--	--
321-7	2000	-	--	--	--	--
321-8	700	S	3.69	17.5	--	--
321-8	2000	-	--	--	--	--
321-9	700	S	3.67	17.4	--	--
321-9	2000	-	--	--	--	--
321-10	700	S	3.67	17.0	--	--
321-10	2000	-	--	--	--	--
321-11	700	S	3.71	17.0	--	--
321-11	2000	2P	3.54	27.2	2.10	65.0
			3.46			
321-12	700	S	3.63	16.8	--	--
321-12	2000	S	3.53	26.4	2.094	56.0
321-13	700	S	3.66	17.0	--	--
321-13	2000	2P	3.49	33.2	2.09	61.0
			3.42			
321-16A	2000	3P	3.50	30.8	2.10	57.0
			3.43			
			3.36			
321-16B	2000	S	3.50	28.8	2.10	44.0
321-16C	700	S	3.63	15.2	--	--
321-17	700	S	3.60	18.7	--	--
321-17B	2000	S	3.49	28.8	2.10	44.0
321-18A	2000	3P	3.50	29.8	2.10	49.0
			3.43			
			3.37			
321-18B	700	S	3.63	15.2	--	--
321-19A	2000	2P	3.54	25.0	2.09	46.0
			3.426			
321-19A	700	S	3.63	17.1	--	--
321-19B	2000	NVS	3.43	39.0	2.10	53.8
321-20A	700	S	3.63	17.5	--	--
321-20A	2000	3P	3.52	28.0	2.10	61.0
			3.42			
			3.36			
321-20B	2000	3P	3.53	37.0	2.10	46.0
			3.426			
			3.37			
321-21A	700	S	3.63	18.0	--	--

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
321-21A	2000	NVS	3.43	41.6	2.10	51.0
321-21B	700	S	3.64	18.4	--	--
321-21B	2000	S	3.52	27.0	2.10	57.0
321-22A	2000	2P	3.52	27.6	2.10	53.0
			3.43			
321-22B	700	S	3.70	16.1	--	--
321-23	2000	S	3.49	33.0	2.10	54.0
321-23A	700	S	3.63	18.4	--	--
321-23B	700	S	3.36	16.5	--	--
321-23B	2000	3P	3.52	29.6	2.10	51.0
			3.43			
			3.36			
321-24	700	S	3.70	15.8	--	--
321-24A	700	S	3.63	16.2	--	--
321-24B	700	S	3.63	16.5	--	--
321-24B	2000	S	3.43	35.4	2.09	57.0
321-25	700	S	3.63	18.4	--	--
321-25	2000	NVS	3.47	30.8	2.10	60.8
321-25A	700	S	3.60	21.0	--	--
321-25A	2000	NVS	3.43	40.2	2.10	60.5
321-26	700	S	3.67	15.0	--	--
321-26	2000	S	3.52	27.2	2.094	48.5
321-26A	700	S	3.63	18.1	--	--
321-26A	2000	S	3.52	27.2	2.094	54.0
321-27	2000	S	3.52	29.8	2.10	51.0
321-29	700	S	3.63	16.8	--	--
321-29	2000	3P	3.49	24.8	2.094	58.0
			3.40			
			3.35			
321-30	700	S	3.63	19.6	--	--
321-31	2300	3P	3.44	49.0	2.10	60.5
			3.41			
			3.37			
321-31A	2300	NVS	3.40	90.0	2.11	58.0
321-31B	2300	3P	3.49	37.0	2.11	69.0
			3.43			
			3.37			
321-31C	700	S	3.60	18.8	--	--
321-31C	2300	3P	3.49	34.5	2.11	69.0
			3.426			
			3.37			
321-31D	700	S	3.63	17.4	--	--
321-31D	2300	S	3.47	37.2	2.11	69.0
321-31E	700	S	3.63	17.4	--	--
321-31E	2300	NVS	3.426	61.6	2.11	69.0
321-31F	700	S	3.60	18.5	--	--
321-31F	2300	S	3.45	44.0	2.10	69.0
321-31G	2300	2P	3.47	35.0	2.10	56.0
			3.43			

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
321-31I	2300	2P	3.49	40.0	2.11	69.0
			3.38			
321-32	700	S	3.60	18.9	--	--
321-34	2300	S	3.42	57.5	2.10	78.5
321-34A	2300	S	3.426	51.4	2.10	42.0
321-36A	2300	S	3.47	53.6	2.11	64.5
321-36B	700	S	3.63	18.2	--	--
321-36C	2300	S	3.43	70.0	2.10	46.0
321-37	2000	S	3.52	30.8	2.10	54.0
321-37A	700	S	3.60	18.1	--	--
321-37B	2000	3P	3.53	27.2	2.10	54.0
			3.44			
			3.36			
321-38B	700	S	3.63	17.7	--	--
321-39	2000	2P	3.48	34.1	2.10	57.0
			3.426			
321-39B	700	S	3.63	16.4	--	--
321-41C	2000	3P	3.49	32.6	2.10	62.5
			3.43			
			3.36			
321-42A	700	S	3.63	18.8	--	--
321-42A	2000	2P	3.49	35.5	2.10	60.5
			3.43			
321-42B	700	S	3.63	16.7	--	--
321-42B	2000	2P	3.50	25.3	2.10	64.4
			3.43			
321-43B	700	S	3.63	19.3	--	--
321-43B	2000	2P	3.49	35.0	2.098	59.4
			3.42			
321-43B_1	2000	2P	3.50	36.8	2.11	59.5
			3.426			
321-43B_2	2000	2P	3.50	33.0	2.10	57.0
			3.43			
321-44A	2000	3P	3.50	30.8	2.10	51.0
			3.43			
			3.36			
321-44B	2000	3P	3.50	29.0	2.10	54.0
			3.43			
			3.36			
321-45A	2200	S	3.49	33.0	2.10	57.0
321-45B	2200	S	3.47	45.5	2.10	40.5
321-46A	2000	2P	3.49	31.7	2.10	60.4
			3.43			
321-46B	2000	3P	3.46	30.8	2.10	51.0
			3.43			
			3.36			
321-46C	2000	3P	3.47	35.6	2.10	51.0
			3.43			
			3.36			

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
321-46D	2000	3P	3.50	31.7	2.10	64.4
			3.43			
			3.36			
321-48A	2000	S	3.50	31.8	2.10	57.0
321-48B	2000	S	3.50	33.0	2.10	64.4
321-48C	2000	S	3.50	33.0	2.10	60.4
321-49A	2000	S	3.49	33.0	2.10	60.4
321-49B	2000	NVS	3.426	51.2	2.10	54.0
321-51	2000	NVS	3.43	91.5	2.11	69.0
321-51A	2000	NVS	3.43	107.5	2.11	68.0
321-52	2000	NVS	3.43	91.2	2.11	60.5
322-1A	2000	3P	3.44	26.4	2.085	57.3
			3.37			
			3.33			
322-1B	2000	S	3.40	41.5	2.085	--
322-2B	1600	S	3.50	23.0	2.085	37.3
322-3B	1600	S	3.53	22.0	2.085	61.0
322-9A	2000	S	3.37	105.0	2.10	49.6
322-9B	2000	S	3.38	117.0	2.09	51.0
322-10A	2000	2P	3.43	33.0	2.085	--
			3.38			
322-10B	2000	2P	3.50	30.8	2.10	69.0
			3.43			
322-10C	2000	2P	3.49	33.4	2.085	--
			3.43			
322-10D	2000	2P	3.50	28.6	2.10	60.0
			3.43			
322-11A	1670	S	3.55	22.0	2.085	51.2
322-11B	1670	S	3.49	23.0	2.085	47.0
322-11B	2000	2P	3.47	33.0	2.085	48.5
322-12A	1600	S	3.56	23.0	2.085	40.5
322-12B	1670	S	3.56	22.0	2.10	57.0
322-13B	1670	S	3.53	31.8	2.085	50.2
322-14A	1670	S	3.50	23.0	2.085	--
322-14B	1670	S	3.56	21.0	2.09	46.0
322-15B	1670	S	3.56	25.0	2.085	48.4
322-16A	1670	S	3.56	23.5	2.085	--
322-16B	1670	S	3.56	22.0	2.085	44.0
322-17A	1670	S	3.56	22.2	2.085	88.0
322-17B	1670	S	3.56	22.0	2.085	51.4
322-18B	1670	S	3.50	28.8	2.085	61.5
322-19B	1670	S	3.56	20.6	2.085	48.5
322-20	1670	S	3.50	21.4	2.085	30.2
322-21B	1670	S	3.56	17.0	2.085	69.5
322-23A	1300	S	3.56	17.4	2.085	--
322-25A	1410	S	3.56	18.5	2.085	46.1
322-25B	1410	S	3.56	19.2	2.07	121.0
322-26A	1410	S	3.50	25.6	2.085	51.0
322-26B	1410	S	3.50	19.2	2.085	40.2

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
322-27A	1410	S	3.59	20.0	2.085	57.3
322-27B	1410	S	3.56	19.3	2.085	--
322-28A	1410	S	3.56	19.4	2.08	40.2
322-28B	1410	S	3.56	17.8	2.085	53.2
322-29	1410	S	3.56	20.1	2.085	40.2
322-29B	1410	S	3.56	21.0	2.085	53.2
322-31A	1410	S	3.56	23.0	2.085	40.4
322-31B	1410	S	3.56	18.8	2.085	54.0
322-32	1350	S	3.56	18.2	2.085	48.5
322-34	1350	S	3.56	19.2	2.085	46.0
322-35	1350	S	3.56	20.6	2.085	54.0
322-36	1543	S	3.56	19.2	2.085	53.0
322-37	1543	S	3.56	23.0	2.085	--
322-40	1440	S	3.53	23.6	2.085	66.0
322-41	1440	S	3.56	20.4	2.085	61.0
322-42A	1440	S	3.56	21.4	2.085	37.1
322-42B	1440	S	3.56	21.4	2.085	65.0
322-46	1440	S	3.53	19.6	2.08	--
322-47A	1440	S	3.50	21.5	2.085	74.0
322-47B	1440	S	3.56	20.0	2.085	51.6
322-48A	1600	S	3.49	21.5	2.085	51.0
322-49	1460	S	3.53	24.4	2.10	49.0
322-49	1600	S	3.52	23.0	2.085	--
322-53A	1460	S	3.56	20.0	2.09	54.2
322-53B	1460	S	3.56	20.0	2.10	--
322-53C	1460	S	3.56	18.4	2.085	49.0
322-54A	1460	S	3.56	18.7	2.085	48.2
322-58	1500	NVS	3.50	21.0	2.085	53.0
322-58A	1500	S	3.49	21.0	2.085	51.0
322-59	1500	S	3.56	24.4	2.085	53.8
322-61	1500	NVS	3.47	37.0	2.09	60.0
322-62	1500	S	3.47	30.8	2.085	97.0
322-62A	700	S	3.56	18.3	--	--
322-63A	1500	S	3.46	35.6	2.10	72.5
322-63	1500	NVS	3.42	31.6	2.10	51.0
322-64	1370	S	3.56	18.5	2.085	54.0
322-66	1370	S	3.56	19.8	2.085	46.0
322-67A	1370	S	3.53	23.0	2.085	53.0
322-67B	1370	S	3.56	20.8	2.085	49.0
322-68A	1370	S	3.56	19.5	2.085	48.0
322-68B	1370	S	3.56	19.6	2.09	51.0
322-69	1370	S	3.56	18.5	2.085	54.0
323-1	1370	S	3.60	18.4	2.08	40.5
323-2	1370	S	3.60	18.4	2.07	44.0
323-2A	1370	S	3.60	18.4	2.07	48.0
323-3	1370	S	3.49	23.0	2.07	51.0
323-3A	1370	S	3.56	19.4	2.08	46.0
323-4	1370	S	3.58	18.9	2.07	54.0
323-4A	1370	S	3.58	20.0	2.07	51.0

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
323-5	1000	S	3.63	16.4	2.07	42.0
323-5A	1000	S	3.63	15.4	2.07	46.0
323-6A	1000	S	3.63	16.8	2.07	42.0
323-6	1000	S	3.63	16.0	2.07	51.0
323-7	1000	S	3.63	18.1	2.07	46.0
323-8	1000	S	3.63	18.4	2.07	44.0
323-8A	1000	S	3.63	17.2	2.07	36.0
323-9	1000	S	3.63	15.6	2.07	44.5
323-9A	1000	S	3.63	16.4	2.07	37.0
323-11A	1000	S	3.63	16.2	2.07	35.0
323-11B	1000	S	3.63	17.7	2.07	37.2
323-11C	1000	S	3.63	17.4	2.07	32.0
323-11D	1000	S	3.63	16.4	2.08	37.2
323-11E	1000	S	3.63	16.7	2.07	39.0
323-11F	1000	S	3.63	16.4	2.07	49.0
323-11G	1000	S	3.63	17.7	2.07	46.0
323-12	1000	S	3.63	17.7	2.07	44.0
323-12A	1000	S	3.63	17.7	2.07	37.0
323-13	1000	S	3.63	18.8	2.07	40.5
323-13A	1000	S	3.63	17.0	2.07	51.0
323-14	1000	S	3.62	16.7	2.08	48.5
323-19	1049	S	3.63	17.7	2.07	37.2
323-20	1049	S	3.63	17.1	2.07	40.5
323-20A	1049	S	3.63	16.8	2.07	51.0
323-21	1049	S	3.63	15.6	2.07	42.0
323-22	1049	S	3.63	16.2	2.07	40.5
323-23	1049	S	3.63	16.5	2.08	51.0
323-24	1049	S	3.63	19.1	2.07	38.6
323-25	1038	S	3.63	16.2	2.07	39.0
323-25A	1038	S	3.63	16.0	2.07	39.0
323-26A	1038	S	3.63	16.2	2.08	42.0
323-26B	1038	S	3.67	16.0	2.08	39.0
323-27	1038	S	3.63	15.5	2.07	42.0
323-27A	1038	S	3.63	16.2	2.08	46.0
323-28	1038	S	3.63	15.0	2.08	40.5
323-29 (low-p)	1038	S	3.63	15.8	2.08	44.0
323-29 (hi-p)	1038	S	3.62	16.8	2.08	40.4
323-29	1038	S	3.67	16.2	2.08	46.0
323-29A	1038	S	3.63	17.4	2.08	44.0
323-30B	1038	S	3.63	17.1	2.07	56.0
323-30C	1038	S	3.63	15.8	2.08	48.5
323-31	1038	S	3.63	21.0	2.08	46.0
323-32	1038	S	3.63	15.6	2.07	42.0
323-32A	1038	S	3.67	16.5	2.08	38.6
323-32B	1038	S	3.67	16.0	2.08	42.0
323-32C	1038	S	3.63	15.6	2.08	42.0
323-32D	1038	S	3.67	16.7	2.08	44.0
323-33	1027	S	3.63	15.0	2.07	38.5
323-34	1038	S	3.63	16.5	2.08	38.6

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
323-35	1027	S	3.67	15.0	2.08	39.0
323-36	1027	S	3.67	15.0	2.08	39.0
323-36	1027	S	3.63	15.0	2.08	40.0
323-38	1027	S	3.67	15.7	2.08	37.4
323-39	700	S	3.70	14.5	--	--
323-40	1000	S	3.70	15.7	2.08	38.0
323-41	1015	S	3.70	16.0	2.08	40.5
323-42	700	S	3.70	16.0	--	--
323-43	1015	S	3.70	15.4	2.08	40.5
323-45	1015	S	3.70	17.9	2.08	43.0
323-46	1000	S	3.70	15.0	2.08	40.5
323-47	1005	S	3.70	15.8	2.08	42.0
323-48	1005	S	3.70	16.0	2.08	42.0
323-49	700	S	3.70	16.0	--	--
323-50	1000	S	3.70	16.0	2.08	42.0
323-51	1000	S	3.67	16.4	2.08	36.0
323-52	700	S	3.70	15.6	--	--
323-53	1080	S	3.62	18.9	2.08	40.5
323-54	700	S	3.63	16.7	--	--
323-55	1027	S	3.63	15.0	2.08	39.0
323-56	700	S	3.70	15.6	--	--
323-57	1000	S	3.63	16.0	2.08	41.0
323-58	1000	S	3.67	15.7	2.08	36.0
323-59	1000	S	3.67	16.0	2.08	40.5
323-58	1080	S	3.63	15.6	2.08	36.0
323-64	700	S	3.63	16.2	2.08	35.0
323-66	1000	S	3.70	15.0	2.08	48.5
323-67	1000	S	3.63	15.0	2.08	36.0
323-68	1000	S	3.70	16.0	2.07	55.0
323-69	1000	S	3.63	16.2	2.08	46.0
324-1	1000	S	3.70	14.0	2.08	39.0
324-2	1000	S	3.67	16.0	2.08	42.0
324-3	1000	S	3.63	16.2	2.08	42.0
324-4	1000	S	3.63	16.8	2.08	38.0
324-5	1000	S	3.67	15.5	2.08	39.0
324-6	1000	S	3.63	16.2	2.08	38.0
324-8	1000	S	3.67	16.4	2.08	37.4
324-9	1000	S	3.67	14.8	2.08	44.0
324-10	1000	S	3.63	16.5	2.08	36.0
324-11	1000	S	3.63	16.5	2.08	41.0
324-13	1000	S	3.63	16.7	2.08	41.0
324-14	1000	S	3.63	16.4	2.08	42.0
324-15	1000	S	3.63	16.0	2.08	42.0
324-16	1000	S	3.63	16.2	2.08	43.0
324-18	1000	S	3.70	16.2	2.08	60.0
324-19 1 hr. vac.	1066	S	3.63	16.5	2.08	40.0
324-19 1 hr. vac.	1550	S	3.63	18.8	2.08	51.0
324-19	1000	S	3.63	15.9	2.07	35.8

Sample Designation	Temp. (°C)	(002) Peak Type	d(002)	Lc	d(10)	La
324-19 1 hr. vac.	1250	S	3.63	15.4	2.07	35.8
324-19 1 hr. vac.	1890	S	3.56	22.4	2.08	57.0
324-20	1060	S	3.63	16.2	2.08	43.0
324-21	1060	S	3.63	15.9	2.08	44.0
324-22	1060	S	3.70	16.0	2.07	40.5
324-23	1060	S	3.70	16.2	2.08	45.0
324-24	1060	S	3.70	16.2	2.08	40.0
324-25A	1060	S	3.70	16.8	2.08	46.0
324-25B	1060	S	3.67	16.7	2.08	41.0
324-25C	1060	S	3.70	16.0	2.08	42.0
324-27D	1060	S	3.70	16.3	2.08	36.0
324-28	1060	S	3.70	15.3	2.07	38.0
324-29	1060	S	3.70	16.0	2.08	40.0
324-30	1060	S	3.70	15.7	2.08	36.0
324-31	1060	S	3.63	16.4	2.08	39.0
324-33G	1082	S	3.63	17.0	2.08	41.0
324-34	1066	S	3.63	16.0	2.08	37.0
324-35	1066	S	3.63	16.4	2.08	37.4
324-36	1066	S	3.63	17.3	2.08	35.6
324-37	1060	S	3.63	16.4	2.08	37.0
324-38	1066	S	3.63	17.0	2.08	41.0
324-39	1066	S	3.63	16.7	2.08	41.0
324-40	1066	S	3.63	15.5	2.08	39.0
324-40A	1066	S	3.63	16.7	2.08	39.0
324-41	1066	S	3.63	16.5	2.08	42.0
324-42	1066	S	3.63	16.7	2.08	44.0
324-43	1066	S	3.63	16.7	2.08	41.0
324-43B4	1440	S	3.60	22.0	2.08	46.0
324-44	1066	S	3.63	16.5	2.08	46.0
324-45	1060	S	3.63	15.3	2.08	39.0
324-47	1066	S	3.63	16.7	2.08	37.4
324-48	1066	S	3.63	15.9	2.08	41.0
324-49	1104	S	3.63	15.6	2.08	42.0
324-51	1104	S	3.67	15.8	2.08	41.0
324-52	1104	S	3.63	17.4	2.07	48.0
324-53	590	S	3.70	14.4	--	--
324-54	1066	S	3.63	15.0	2.08	39.0
324-56	1066	S	3.63	15.0	2.08	42.0
324-58	1066	S	3.63	15.0	2.08	39.0
324-59	1066	S	3.63	16.0	2.08	49.0
324-61	1066	S	3.63	16.0	2.08	37.0
324-62	1066	S	3.63	15.6	2.08	44.0
324-63	1066	S	3.67	16.0	2.08	40.5
324-65	1066	S	3.63	16.5	2.08	39.0
324-66	1066	S	3.63	16.5	2.08	46.0

TABLE 2 Sizes of the Structural Features Observed in Bright and Dark Field Electron Micrographs Compared to Crystallite Sizes Obtained from X-ray Analysis

Sample #	Platelet Dia. Å	Granulation* Dia. Å	Dark Field Dia. Å** (002)	Dark Field Dia. Å** (100)	X-ray (Å) Lc	X-ray (Å) La	(002) Peak Type
311-19(2000)	150-500	30-40	20-40	--	--	--	--
311-19(750)[x]	150-350	20-30	--	--	14	19	S
312-31(2000)	200-500	20-45	20-45	--	27.6	56	S
312-31(2000)	150	35	30	>100	28	56	S
317-24(2000)	250	42	60†	--	24	45	NVS
317-29(2000)	>250	60	30-70†	--	65-75	--	NVS
317-33(2000)	250-500	35	--	--	92	49	S
317-45(2000)	>500	30	--	--	25	60	3P
317-48(2000)[x]	250	55	--	--	34	59	3P
317-49(2000)[x]	250-500	45	40†	--	33	60	3P
318-12(2000)	250-500	60	50	110†	31	59	3P
318-22(2000)	>500	40-60	35	--	65	55	NVS
318-22(700)	250	--	--	--	15.7	--	S
318-23(2000)	250	50	50	--	63	73	S
318-23(700)	--	--	--	--	16	--	S
318-29(2000)[x]	>500	30-40	60	--	31	63	2P
321-31C(2000)[x]	250	35	60	80	35	69	3P
321-31D(2300)	250	40	35	80	37	69	S

*Diameter corresponds to distances between nearest neighbor.
**Diameter of diffracting regions obtained from (002) or (100) diffraction halos.
†Some of the crystallites giving rise to halos or spots are very large in size, i.e., up to 500Å.
[x]A second structural feature was observed in the bright field micrographs of these samples. This new feature appeared to be long regular cylinders 500Å in diameter by about 1μ long. Regular striations along the length were spaced 45Å apart.

TABLE 3 Electron Diffraction Results Compared to X-ray Diffraction Results for d(002) and d(10) Spacings (Å)

Sample #	X-ray d(002)	X-ray d(10)	Electron Diffraction d(002)	Electron Diffraction d(10)	(002) Peak Type
Graphite	3.35	2.13	3.37	2.12	--
311-19(2000)	3.56	2.17	3.45	2.09	--
311-19(750)	3.70	2.19	--	2.07	S
312-31(2000)	3.54	2.12	3.53	2.16	S
	3.57	2.10	3.53†	2.12	S
317-24(2000)	3.50	2.10	3.53†	2.10†	NVS
317-29(2000)	3.43	--	3.35†	2.12	NVS
			3.45		
317-33(2000)	3.414	2.10	3.35†	2.10	S
317-45(2000)	3.35	2.09	3.50	2.10	3P
	3.48				
317-48(2000)	3.46	2.10	3.48†	2.12	3P
317-49(2000)	3.48	2.09	3.48†	2.10	3P
318-12(2000)	3.49	2.09	3.47†	2.11	3P
318-22(2000)	3.44	2.10	3.37†	2.07	NVS
318-22(700)	3.70	--	3.50	2.11	S
			3.42†		
318-23(2000)	3.43	2.10	3.50†	2.10	S
318-23(700)	3.74	--	--	2.07	S
318-29(2000)	3.45	2.08	3.45	2.12	2P
321-31C(2300)	3.43	2.11	3.56†	2.12	3P
321-31D(2300)	3.47	2.11	3.50*	2.125	S

*In this sample no spots were seen on any diffraction halo.
†In addition to Debye-Scherrer rings, a number of sharp diffracting spots were observed on or close to the ring.

TABLE 7

Sample #	Temp.°C	He Density (gm/cm^3)	Surface Area Knudsen Flow (m^2/gm)	Specific Surface Area (m^2/gm)
311-32	2000	1.41	3.0	26.4
317-9	700	1.83	--	506.0
317-9	2000	1.70	12.5	59.9
317-12	700	1.80	9.1	510.0
317-12	2000	1.72	--	109.0
318-22	700	1.79	--	459.0
318-22	2000	1.51	--	49.6
321-9	700	1.46	--	541.2
321-9	2000	1.28X*	--	12.7
321-13	367	--	--	257.0
321-13	700	--	--	852.3
321-13	1066	1.56X	--	72.4
321-13	1227	1.54X	--	56.6
321-13	1504	1.50X	--	51.3
321-13	1795	1.44X	--	47.9
321-24B	2000	1.48X	--	61.3
321-25A	2000	1.45X	--	36.9
323-8	1000	1.51X	--	3.3
323-26A	1038	1.46X	--	--
323-50	1000	1.51X	--	203.0

*X indicated Xylene

TABLE 8

Sample #	Temp.°C	ρ_{He} real[1] (g/cc)	ρ_{Hg} real[2] (g/cc)	ρ_{Hg} app. (g/cc)	MPD (μ)	IPV (cc/g)
GC No.1		1.47	1.482	1.424	.003	.0273
302-5	2320	--	1.509	.647	2.97	.8828
302-12	2320	--	1.501	.559	3.62	1.1224
305-6 6.62 Mo	2000	1.94	1.802	.636	2.54	1.0151
305-12	2000	1.55	1.562	.557	4.19	1.1560
305-18 .4 Mo	2000	1.77	1.718	.606	2.49	1.0678
308P-2 #2		1.586	1.505	1.034	.009	.3030
308P-3 #3		1.611	1.486	1.077	.008	.2559
310-1	1000	1.27	1.446	.814	.023	.5411
310-3	1000	--	1.424	.805	.020	.5454
310-17A	2000	1.50	1.175	.639	.119	.7130
310-18	1000	1.48	1.452	.687	.039	.7666
310-18	2000	1.15	1.366	.648	.044	.8110
310-20	2000	1.09	1.458	1.029	.009	.2855
310-29	2000	1.89	1.533	.944	.014	.3959
311-21	2000	1.59	1.339	.731	.038	.6221
311-22	2000	1.00	.847	.484	.154	.8809
312-19A	730	1.20	1.481	.879	.629	.4626
312-29	728	1.52	1.441	1.038	.014	.2709
312-31	2000	1.41	1.490	.923	.025	.4118
312-45	2000	1.26	1.302	1.214	.005	.0540
312-48	2000	1.53	1.392	.861	.121	.4425
312-49	2000	1.34	1.404	1.031	.011	.2579
315-1	2000	1.50	1.431	.962	47.0	.3412
317-5	2000	1.42	1.313	.873	.071	.4039
317-18	2000	1.50	1.255	.953	39.1	.281
318-22	700	1.79	1.426	.771	.057	.5958
318-22	2000	1.51	1.576	.937	.054	.4334
318-45	2000	1.37X	1.20	.78	.0078	.021
321-7	2000	1.54	1.04	.76	.028	.34714
321-9	700	1.46	1.24	.98	.0073	.205
321-9	2000	1.36	1.4	1.2	.0057	.016
321-13	700	--	2.00	.96	.042	.49883
321-13	1504	1.50X[3]	1.09	.51	.046	.48293
321-13	1795	1.44X	1.24	.77	.044	.47032
321-17	2000	1.43	1.17	.59	2.15	.299
321-18	2000	1.67	1.16	.87	.175	.247

*Glassy Carbon No. 1 - Le Carbone, p. 6927.
[1]Real density as determined by He pycnometry
[2]Real density as determined by Hg
[3]X indicates Xylene

Sample #	Temp. °C	ρ_{He} real[1] (g/cc)	ρ_{Hg} real[2] (g/cc)	ρ_{Hg} app. (g/cc)	MPD (μ)	IPV (cc/g)
321-19	2000	1.80	1.56	.98	.049	.379
321-20	2000	1.60	1.63	.70	.088	.345
321-21	2000	1.79	1.30	.85	.041	.377
321-25	2000	--	2.20	1.14	.011	.088
321-31	2000	1.41	1.49	1.34	.0195	.075
322-14A	1300	--	--	--	2.2	.826
322-14A	1412	1.74	--	--	1.7	.494
322-14B	1300	--	--	--	2.3	.501
322-14B	1412	--	--	--	1.5	.496
322-17A	1300	--	--	--	4.5	.604
322-17A	1412	--	--	--	4.4	.271
322-17B	1300	--	--	--	2.5	.382
322-17B	1412	--	--	--	2.0	.534
322-19A	1300	--	--	--	1.0	.461
322-19A	1412	1.9	--	--	.08	.472
322-19B	1300	--	--	--	.65	.466
322-19B	1412	--	--	--	.95	.468
322-20	1300	--	--	--	1.8	.432
322-20	1412	1.57X	--	--	1.5	.666
322-21A	1300	1.50X	--	--	18.0	.503
322-21A	1412	--	--	--	3.5	.420
322-21B	1412	1.52X	--	--	10.0	.400
322-21D	1300	--	--	--	8.0	.780
322-22A	1300	--	--	--	1.1	.308
322-22A	1412	1.48X	--	--	1.2	.443
322-22B	1300	--	--	--	1.4	.457
322-22B	1412	1.49X	--	--	1.2	.440
322-23A	1300	1.55X	--	--	1.5	.443
322-23A	1412	1.47X	--	--	1.2	.458
322-23B	1300	2.08X	--	--	.32	.453
322-23B	1412	1.61X	--	--	.35	.458
322-24A	1300	1.54X	--	--	1.3	.395
322-24A	1412	--	--	--	1.3	.563
322-24B	1300	--	--	--	1.9	.620
322-24B	1412	1.59X	--	--	1.4	.888
322-32	1350	1.60X	--	--	1.4	.571
322-35	1350	1.43X	--	--	6.0	.472
322-41	1440	1.59X	--	--	.07	.669
322-45	1500	1.72X	--	--	4.2	.421
322-46	1500	1.48X	--	--	1.4	.550
322-47A	1500	1.47X	--	--	1.3	.652
322-48	1605	1.53X	--	--	6.0	.634
322-49	1400	--	--	--	7.0	.841
322-49	1400	--	--	--	7.0	.607
322-49	1600	1.51X	--	--	7.0	.595
322-50	1600	1.52X	--	--	6.0	.545
322-50	1400	1.48X	--	--	6.0	.679
323-26A	1038	1.46X	1.37	.53	1.27	.497

TABLE 9

Physical Properties

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resistivity Ω-cm (×10)	Hardness (DPH)	Int. Frict. (×10³)	Sonic Mod. psi (×10⁻⁶)	Compr. Str. psi (×10⁻³)	Ult. Str. psi (×10⁻³)
310-35	2000	(0.57)*	--	2.07	--	--	--	--	5.18	1.01
311-34	2000	(0.60)	--	--	--	--	--	--	7.2	7.04
311-35	2000	0.51			.294	--	1.43	0.35	6.85	1.23
312-13	2000	(1.07)	--	--	--	--	--	--	50.0	4.85
312-14	2000	(1.00)	1.44	--	--	--	--	--	36.0	--
312-16	2000	(0.77)	1.27	1.45	--	--	--	--	1.73	2.83
312-27	2000	(1.15)	--	--	--	--	--	--	--	7.78
312-29	2000	(1.07)	1.52	--	--	--	--	--	39.7	--
312-32	2000	(0.90)	1.47	--	--	--	--	--	29.2	5.13
312-33	2000	--	1.59	--	--	90	--	--	--	--
312-34	2000	(0.92)	1.38	--	--	--	--	--	27.3	1.11
312-44	2000	--	1.18	1.22	--	98	--	--	--	--
312-45	680	--	--	--	--	135	--	--	--	--
312-45A	2000	--	1.26	1.29	--	176	--	--	--	--
312-46	680	--	--	--	--	107	--	--	--	--
312-46	2000	--	--	--	--	105	--	--	--	--
312-49	2000	(1.10)	1.3	1.45	--	--	--	--	--	5.96
315-1	2000	(0.89)	1.49	--	--	--	--	--	--	--
315-2	2000	0.70	1.52	--	.349	--	--	1.27	1.47	0.36
315-3	2000	--	1.38	1.49	--	--	--	--	--	--
315-4	2000	--	1.55	--	--	--	--	--	--	--
315-14	2000	(0.96)	1.6	--	--	--	--	--	47.7	4.7
315-17	2000	(0.79)	--	1.45	--	--	--	--	29.3	2.51
315-20	2000	(0.84)	1.6	--	--	--	--	--	--	--
315-20A	2000	0.84	1.6	--	.180	--	0.93	1.48	--	--
315-20B	2000	0.77	1.60	--	.275	--	1.63	1.37	--	--

*Data in parenthesis obtained from unmachined cylinders. All other densities from machined cylinders.

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resistivity Ω-cm (×10)	Hardness (DPH)	Int. Frict. ($\times 10^3$)	Sonic Mod. psi ($\times 10^{-6}$)	Compr. Str. psi ($\times 10^{-3}$)	Ult. Str. psi ($\times 10^{-3}$)
315-20C	2000	0.88	1.60	--	.203	--	0.54	1.52	--	--
315-21B	2000	(0.96)	--	1.37	--	--	--	--	--	6.60
315-21C	2000	0.91	1.52	--	.147	--	0.26	1.54	46.8	7.13
315-21D	2000	(1.01)	--	1.47	--	--	--	--	27.0	7.62
315-22	2000	(0.90)	1.63	1.46	--	--	--	--	--	--
315-24	2000	(1.15)	1.78	--	--	--	--	--	--	--
315-25A	2000	(0.88)	--	1.43	--	--	--	--	24.3	4.61
315-25B	2000	(0.87)	--	1.58	--	--	--	--	--	4.78
315-25C	2000	0.88	1.41	--	.317	--	2.38	1.55	35.5	7.38
315-26B	2000	(0.88)	--	1.45	--	--	--	--	30.5	6.63
315-26C	2000	0.80	1.45	--	.057	--	--	1.20	25.6	4.24
315-26D	2000	0.83	1.45	--	.149	--	--	1.38	36.6	--
315-28	2000	(0.96)	1.46	--	--	--	--	--	37.3	4.39
315-30	2000	(0.91)	1.49	--	--	--	--	--	--	--
315-31	2000	(0.85)	1.48	--	--	--	--	--	--	--
315-31B	2000	0.80	1.46	--	.119	--	0.33	1.44	35.1	5.15
315-31C	2000	0.93	1.48	--	.237	--	0.47	1.65	--	--
315-31D	2000	0.91	1.46	--	.229	--	0.42	1.60	36.2	6.6
315-32	2000	(0.99)	1.43	--	--	--	--	--	45.0	6.35
315-33	2000	0.78	1.50	--	.195	--	1.50	1.26	--	--
315-34C	2000	0.60	1.58	--	.294	--	0.31	0.87	21.0	2.95
315-34D	2000	0.66	1.57	--	.137	--	2.01	1.22	16.4	2.73
315-35B	2000	(0.87)	1.89	1.75	--	--	--	--	--	--
315-37	2000	0.53	1.61	1.48	.262	--	0.31	0.61	14.2	2.51
315-38	2000	(0.72)	1.51	--	--	--	--	--	--	--
315-38A	2000	0.72	1.51	--	.237	--	--	0.93	2.40	2.97
315-39A	2000	0.96	1.64	1.43	.188	--	0.47	1.78	35.9	5.59
315-39B	2000	0.96	1.64	1.43	.029	--	1.28	1.76	28.5	4.41
315-40	2000	(0.87)	1.33	1.41	--	--	--	--	--	--
315-41	2000	0.68	1.67	1.41	.220	--	--	--	15.0	--
315-41A	2000	0.77	1.67	--	.038	--	1.18	1.35	18.6	2.0
315-41B	2000	0.79	1.67	--	.157	--	0.98	1.28	16.0	2.02
315-42	2000	0.87	1.83	1.47	.249	--	0.35	1.65	--	--

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resistivity Ω-cm (×10)	Hardness (DPH)	Int. Frict. ($\times 10^3$)	Sonic Mod. psi ($\times 10^{-6}$)	Compr. Str. psi ($\times 10^{-3}$)	Ult. Str. psi ($\times 10^{-3}$)
315-43	2000	(1.04)	--	1.48	--	--	--	--	50.0	--
315-44	2000	0.76	1.78	1.43	.214	--	0.32	1.43	--	--
315-45	2000	(0.88)	1.39	1.49	--	--	--	--	--	--
315-45B	2000	0.76	--	1.67	.039	--	0.28	5.8	--	--
315-46	2000	(1.094)	--	1.51	--	240	--	--	--	--
315-46	2000	(1.094)	--	1.51	--	105	--	--	--	--
315-46A	2000	(.899)	1.55	--	--	58	--	--	2.5	2.23
317-1	2000	(1.21)	1.67	1.21	--	--	--	--	56.5	7.5
317-2	2000	0.71	1.74	1.45	.088	--	--	0.91	23.7	2.97
317-5	2000	(0.78)	1.42	1.31	--	58	--	--	33.1	7.50
317-6	2000	(0.78)	1.88	1.45	--	--	--	--	--	--
317-7	2000	(0.79)	1.82	1.43	--	--	--	--	--	--
317-8	2000	1.00	1.64	1.44	--	--	--	1.82	40.5	2.29
317-9	2000	(0.93)	1.76	--	--	--	--	--	32.3	5.77
317-10	2000	0.79	1.42	--	.009	--	0.75	1.45	43.7	6.00
317-12	2000	(0.89)	1.60	--	--	--	--	--	--	5.82
317-13	2000	(0.88)	1.88	1.45	--	--	--	--	--	--
317-14	2000	(0.87)	1.49	--	--	--	--	--	27.4	4.69
317-15	2000	(0.91)	1.46	--	--	--	--	--	33.6	4.09
317-18	2000	0.72	1.50	1.26	.088	--	0.39	0.86	5.1	3.30
317-19	2000	(1.13)	1.68	--	--	--	--	--	28.2	8.75
317-20	2000	(1.05)	1.51	--	--	--	--	--	--	--
317-23	2000	(0.83)	--	1.46	--	--	--	--	7.6	1.90
317-24	2000	0.76	1.57	--	.187	--	0.76	1.45	49.1	4.37
317-25	2000	(0.88)	1.69	1.41	--	--	--	--	34.1	2.85
317-26	2000	0.78	1.48	--	.195	14	0.66	1.51	4.7	0.92
317-27	2000	--	--	--	--	--	--	--	37.3	--
317-28	2000	(0.93)	1.7	1.45	--	--	--	--	--	--
317-29	2000	0.74	1.65	1.49	.122	--	--	0.86	16.4	2.48
317-30	2000	(0.77)	1.68	1.51	--	--	--	--	--	--
317-31	2000	(0.70)	1.45	--	--	--	--	--	--	--
317-32	2000	0.89	1.72	1.43	.224	--	--	1.64	44.2	5.05
317-33	2000	(1.02)	1.46	--	--	73	--	--	40.2	5.60

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resis-tivity Ω-cm (×10)	Hard-ress (DPH)	Int. Frict. (×10³)	Sonic Mod. psi (×10⁻⁶)	Compr. Str. psi (×10⁻³)	Ult. Str. psi (×10⁻³)
317-34	2000	0.65	1.56	1.50	.321	--	--	2.07	24.0	4.61
317-35	2000	(0.98)	1.40	--	--	--	--	--	--	--
317-37	2000	0.90	1.34	1.43	.225	80	0.31	1.61	40.6	6.90
317-38	2000	0.90	1.34	1.43	.268	62	1.27	1.01	37.6	4.20
317-39	2000	0.77	1.27	--	.032	49	0.19	1.20	26.7	3.58
317-40	2000	0.85	1.47	--	.184	--	--	1.25	22.8	3.44
317-41	2000	(0.93)	--	1.59	--	--	--	--	10.0	2.35
317-41A	2000	(0.90)	--	1.37	--	--	--	--	7.4	1.91
317-41B	2000	(1.12)	1.48	--	--	--	--	--	27.0	3.90
317-42	2000	0.87	1.45	--	.135	53	--	1.54	39.8	5.30
317-43	2000	(0.90)	1.40	--	--	--	--	--	15.0	2.47
317-44	2000	0.84	1.51	--	.007	52	1.68	1.35	27.3	2.13
317-45	2000	(0.88)	1.40	--	--	--	--	--	32.3	5.2
317-46	2000	0.81	1.48	--	.112	71	--	1.27	34.6	4.95
317-47	2000	(0.97)	1.39	--	--	49	--	--	27.5	5.62
317-48	2000	1.16	1.46	--	--	--	--	1.23	--	--
317-49	2000	0.80	1.51	--	.34	--	1.31	0.89	11.1	3.0
318-1	2000	0.79	1.51	--	.169	--	--	0.71	--	2.56
318-2	2000	(0.95)	1.45	--	--	--	--	--	--	--
318-2C	680	0.89	--	--	907.0	--	--	0.80	34.5	4.77
318-3	2000	--	1.37	1.51	--	--	--	--	--	--
318-6A	2000	(1.17)	1.45	--	--	--	--	--	--	--
318-7	2000	0.78	--	1.34	.165	--	--	0.65	.82	1.67
318-8	2000	(0.96)	1.49	--	--	60	--	--	18.2	5.62
318-8A	2000	(0.97)	--	1.49	--	--	--	--	32.7	--
318-9	2000	(0.96)	1.50	--	--	56	--	--	27.4	5.19
318-10	2000	(0.99)	1.48	--	--	--	--	--	--	--
318-11	2000	0.91	1.58	--	--	51	--	1.48	--	5.09
318-12	2000	(0.98)	1.50	--	--	61	--	--	--	--
318-13	2000	(1.03)	--	1.23	--	71	--	--	--	--
318-14	2000	0.77	1.47	--	.285	31	0.41	0.41	4.74	0.83
318-15	2000	(0.95)	1.51	--	--	40	--	--	--	--
318-16	2000	0.94	1.48	--	.270	47	--	1.43	28.2	4.02

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resistivity Ω-cm (×10)	Hardness (DPH)	Int. Frict. ($\times 10^3$)	Sonic Mod. psi ($\times 10^{-6}$)	Compr. Str. psi ($\times 10^{-3}$)	Ult. Str. psi ($\times 10^{-3}$)
318-17	2000	0.74	1.46	--	.189	53	0.18	1.18	33.2	4.35
318-18	2000	--	1.48	--	--	46	--	--	--	--
318-18B	2000	--	--	--	--	--	--	--	--	5.28
318-19	2000	(0.77)	1.41	--	--	--	--	--	--	--
318-20	2000	--	1.50	--	--	65	--	--	--	--
318-21	2000	--	1.37	1.49	--	56	--	--	--	--
318-22	2000	0.83	1.45	--	.237	44	--	1.29	29.5	4.37
318-22	700	(0.78)	1.48	--	--	39	--	--	--	--
318-23	2000	(0.91)	1.49	--	--	54	--	--	--	--
318-24	2000	0.97	1.29	1.52	--	61	--	1.49	--	--
318-24C	2000	0.92	1.29	1.53	--	--	--	--	25.0	4.47
318-26	2000	(0.98)	1.59	--	--	70	--	--	--	--
318-27	2000	(0.87)	1.38	--	--	--	--	--	--	--
318-28	2000	0.84	1.45	--	.177	--	--	1.33	--	--
318-29	2000	0.63	1.45	--	.194	26	--	--	0.23	0.73
318-30	2000	1.08	1.49	--	--	60	--	1.52	21.9	5.82
318-31	2000	0.55	1.31	1.36	.216	21	2.41	0.135	1.6	0.19
318-32	2000	(0.84)	1.57	--	--	53	--	--	19.7	--
318-33	2000	0.80	--	1.53	.101	57	0.73	1.37	32.2	4.75
318-34	2000	1.07	1.45	--	--	--	--	--	28.7	4.85
318-35	2000	0.88	1.43	--	.118	--	--	1.48	26.4*	4.57
318-36	2000	1.02	1.41	--	.107	67	--	1.35	18.6*	3.34
318-37	2000	0.92	1.48	--	.112	--	--	2.17	25.7*	3.90
318-38	2000	--	1.52	--	--	--	--	--	--	--
318-39	2000	1.23	1.57	--	.085	--	--	2.99	34.9*	7.95
318-41	2000	(1.05)	1.44	--	--	--	--	--	--	--
318-43	2000	(1.08)	--	1.42	--	106	--	--	--	--
318-44	2000	(1.09)	--	1.46	--	103	--	--	--	--
318-45	2000	1.27	--	1.37	.070	--	--	3.1	--	--
318-46	2000	1.02	--	1.46	.41	56	--	2.34	42.3*	7.35
318-48	2000	1.08	1.43	--	--	--	--	--	3.5	8.27

*Head speed .05 in/min., all others .02 in/min.

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resistivity Ω-cm (×10)	Hardness (DPH)	Int. Frict. (×10³)	Sonic Mod. psi (×10⁻⁶)	Compr. Str. psi (×10⁻³)	Ult. Str. psi (×10⁻³)
318-50	2000	--	--	--	--	--	--	--	--	5.73
318-51	2000	(0.88)	1.43	--	--	--	--	0.83	17.3	1.44
318-52	2000	1.01	1.41	--	.130	--	--	1.66	17.7	2.54
318-53	2000	(0.87)	1.42	--	--	--	--	--	4.73	1.60
318-56	2000	(0.85)	1.34	1.43	--	--	--	--	--	--
318-58	2000	0.98	--	1.51	.237	--	--	0.10	--	6.02
318-59	2000	0.99	1.38	1.38	--	--	--	2.15	31.7	4.20
318-60	2000	0.95	1.71	1.42	.150	54	--	1.78	36.2*	7.63
318-61	2000	1.01	1.75	1.38	.403	--	--	1.47	22.6*	3.96
318-62	2000	0.90	1.39	--	--	69	--	--	41.4	6.98
321-1B	2000	--	--	--	--	--	--	--	4.36	.87
321-3	2000	0.98	1.57	--	.340	78	--	--	40.0*	7.18
321-5	2000	(0.99)	1.52	--	--	--	--	--	--	--
321-6	2000	1.09	1.60	--	.31	81	--	2.33	41.7*	8.27
321-7	2000	(0.91)	1.54	--	--	--	--	--	--	--
321-8	2000	0.90	1.46	--	.546	105	--	1.48	38.9*	7.00
321-9	2000	1.17	1.36	1.28	--	120	--	--	54.2	9.75
321-10	2000	1.26	1.34	--	.100	99	--	2.99	54.9*	10.85
321-11	2000	0.95	1.43	--	.114	95	--	1.54	40.5	5.16
321-11C	2000	--	--	--	--	132	--	--	37.0	6.08
321-12	2000	0.97	1.32	--	.121	--	--	1.22	14.9	2.52
321-13	2000	0.95	1.48	1.50	.115	131	--	1.67	36.2	6.04
321-15	2000	(0.96)	1.56	--	--	--	--	--	34.5	5.98
321-16A	2000	(0.85)	1.84	--	--	--	0.21	1.55	24.3	4.52
321-16B	2000	(0.93)	1.75	1.39	--	--	--	--	--	--
321-17B	2000	(0.94)	1.41	--	--	--	0.22	1.81	36.7	5.26
321-18A	2000	(0.95)	1.67	1.42	--	--	--	--	--	--
321-18B	2000	(0.64)	--	1.49	--	--	0.2	1.73	39.6	5.67
321-19A	2000	(0.87)	1.68	1.42	--	115	0.15	1.83	31.5	6.04
321-19B	2000	(0.83)	1.80	1.46	--	87	0.11	1.49	31.4	5.76
321-20A	2000	(0.99)	1.72	1.41	--	--	--	--	--	--

*Head speed .05 in/min., all others .02 in/min.

Sample #	Temp.°C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resis-tivity Ω-cm (×10)	Hard-ness (DPH)	Int. Frict. ($\times10^3$)	Sonic Mod. psi ($\times10^{-6}$)	Compr. Str. psi ($\times10^{-3}$)	Ult. Str. psi ($\times10^{-3}$)
321-20B	2000	(0.70)	1.50	--	--	--	--	--	34.8	6.21
321-21A	2000	0.94	1.74	1.45	.2	--	--	1.65	45.5	6.35
321-21B	2000	1.00	--	1.47	.2	--	--	1.93	46.4	6.16
321-22A	2000	0.94	1.79	1.44	.28	--	--	1.44	31.9	6.14
321-22B	2000	(0.98)	--	1.54	--	--	--	--	34.8	4.58
321-22C	2000	0.93	--	1.50	.17	--	--	1.43	36.1	4.35
321-22D	2000	0.92	--	1.47	.19	--	--	1.42	33.7	5.15
321-23	2000	1.04	1.74	--	.12	--	--	2.05	58.6	7.28
321-23A	2000	0.96	--	1.53	.27	--	--	1.64	40.9	6.36
321-23B	2000	0.97	1.77	1.44	.18	--	--	1.69	42.7	5.98
321-24	2000	1.02	--	1.60	.19	--	--	1.95	47.8	6.39
321-24A	2000	0.95	--	1.46	.14	--	--	1.05	49.1	7.04
321-24B	2000	1.07	--	1.48	.15	--	--	2.22	45.1	6.76
321-25A	2000	0.70	--	1.45	.13	--	--	0.68	27.9	5.14
321-26	2000	(0.50)	1.43	1.56	--	--	--	--	26.4	0.77
321-26A	2000	(0.45)	1.54	--	--	--	--	--	--	--
321-27	2000	0.86	1.52	--	.11	--	--	0.62	9.7	1.34
321-29	2000	0.96	1.64	1.42	.18	--	--	1.59	40.0	5.94
321-31	2300	(0.81)	1.41	--	--	--	--	--	--	--
321-31A	2300	(0.97)	1.40	--	--	--	--	--	--	--
321-31B	2300	(0.91)	1.56	--	--	--	--	--	--	--
321-31C	2300	(0.88)	1.41	--	--	--	--	--	--	--
321-31D	2300	--	--	1.53	--	--	--	--	33.3	4.08
321-31F	2300	0.75	--	1.68	.23	--	--	0.70	13.6	2.23
321-31G	2300	1.03	1.66	--	.18	--	--	--	22.2	3.53
321-31I	2300	(1.02)	1.48	--	--	--	--	--	--	--
321-31J	2000	0.91	--	1.48	.16	--	--	1.15	22.6	3.99
321-31P	2000	0.89	--	1.25	.24	--	--	1.16	25.0	3.60
321-31Q	2000	0.98	--	1.53	.17	--	--	1.64	40.5	6.23
321-31R	2000	0.87	--	1.48	.18	--	--	0.85	12.2	1.85
321-31S	2000	0.96	--	1.39	.17	--	--	1.53	36.9	5.58
321-32A	2000	0.94	1.36	1.50	.18	--	--	0.91	35.5	3.78
321-32B	2000	0.93	1.30	1.52	.20	--	--	0.92	36.9	5.76

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resis-tivity Ω-cm (×10)	Hard-ness (DPH)	Int. Frict. (×10³)	Sonic Mod. psi (×10⁻⁶)	Compr. Str. psi (×10⁻³)	Ult. Str. psi (×10⁻³)
321-32C	2000	0.92	1.25	1.50	.21	--	--	0.93	41.4	6.11
321-32D	2000	0.92	--	1.47	.25	--	--	1.49	--	--
321-32D$_1$	2000	0.84	--	1.47	.29	--	--	0.2	--	--
321-32E	2000	0.94	1.33	--	.24	--	--	1.56	41.9	5.89
321-32F	2000	(0.96)	--	1.54	--	--	--	.91	33.3	4.28
321-32G	2000	0.95	--	--	.22	--	--	1.56	31.8	4.53
321-33A	2000	0.94	1.41	--	.16	--	--	--	39.8	5.96
321-33B	2000	0.89	--	1.47	.33	--	--	1.49	53.6	6.69
321-34	2300	(0.95)	1.6	--	--	--	--	--	--	--
321-34A	2300	0.96	1.59	--	.27	--	--	1.49	51.3	7.55
321-34B	2300	0.94	--	1.59	.18	--	--	2.94	33.3	2.92
321-34D	2300	0.95	--	1.49	--	--	--	1.46	--	--
321-34E	2300	0.95	1.21	--	.38	--	--	0.92	40.9	5.43
321-36A	2300	(1.11)	1.80	1.44	--	--	--	--	--	2.46
321-36B	2300	1.07	1.66	1.35	.29	--	--	1.15	50.4	7.23
321-36C	2300	(1.11)	1.43	--	--	--	--	--	--	--
321-37	2300	(1.07)	1.41	--	--	--	--	--	--	--
321-37B	2300	.66	1.50	--	.24	--	--	0.42	5.53	1.09
321-37D$_1$	2300	--	--	--	--	--	--	--	2.51	0.45
321-37E	2300	0.79	--	1.76	.44	--	--	0.94	1.39	0.36
321-37F	2300	0.65	--	1.56	--	--	--	0.08	1.05	0.22
321-37Q	2300	0.71	--	1.62	.31	--	--	0.2	1.67	0.40
321-39	2300	0.84	1.60	--	.23	--	--	0.72	6.80	1.31
321-40	2300	(0.60)	1.42	--	.30	--	--	--	0.50	.06
321-41B	2300	(0.77)	1.51	--	--	--	--	--	--	--
321-42A	2000	0.77	--	1.44	.29	--	--	0.35	2.05	0.57
321-42B	2000	0.65	1.48	--	.28	--	--	0.20	1.14	0.42
321-43A	2200	0.73	1.55	--	.36	--	--	0.60	1.31	0.37
321-43B	2200	0.61	1.44	--	.46	--	--	0.10	0.73	0.22
321-44A	2200	(0.96)	1.81	1.46	--	--	--	--	--	--
321-44B	2200	(0.98)	1.56	--	--	--	--	--	--	--
321-45A	2200	(1.17)	1.78	1.42	--	--	--	--	--	--
321-45B	2200	(1.06)	1.84	1.50	.09	--	--	0.42	41.50	5.93

Sample #	Temp.°C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resistivity Ω-cm (×10)	Hardness (DPH)	Int. Frict. ($\times 10^3$)	Sonic Mod. psi ($\times 10^{-6}$)	Compr. Str. psi ($\times 10^{-3}$)	Ult. Str. psi ($\times 10^{-3}$)
321-46A	2200	(0.83)	1.40	--	--	--	--	--	--	--
321-46B	2200	0.82	1.43	--	.26	--	--	0.16	2.04	0.49
321-46C	2200	(0.87)	1.60	--	--	--	--	--	--	--
321-47A	1600	(1.13)	2.07	1.48	--	--	--	--	--	--
321-47B	1600	(1.18)	1.67	--	--	--	--	--	--	--
321-47C	1600	(0.91)	1.84	1.45	--	--	--	--	--	--
321-48A	1600	(0.79)	1.40	--	--	--	--	--	--	--
321-48B	1600	0.83	1.43	--	.24	--	--	0.34	2.65	0.60
321-48C	2000	(0.78)	1.58	--	--	--	--	--	--	--
321-49A	1600	(0.91)	1.51	--	--	--	--	--	--	--
321-49B	1600	(0.80)	1.44	--	--	--	--	--	--	--
321-49C	1600	(0.91)	1.51	--	--	--	--	--	--	--
321-50	1600	(1.00)	1.69	--	--	--	--	--	--	--
321-50B	1600	1.02	1.43	--	.15	--	--	1.5	28.2	4.52
321-50C	16[illegible]	(1.03)	1.45	--	--	--	--	--	--	--
321-51	2350	(0.99)	1.50	--	--	--	--	0.73	9.1	1.36
321-51A	2350	0.96	1.53	--	.21	--	--	--	--	--
321-52	2000	--	1.3	1.52	--	--	--	--	--	--
321-53	2000	(1.12)	2.07	1.47	--	--	--	--	--	--
322-1A	1600	0.82	--	1.59	.24	--	--	0.27	4.00	0.78
322-1B	1600	0.83	1.98	--	.39	--	--	0.26	--	--
322-2A	1600	(0.87)	2.02	1.59	--	--	--	--	--	--
322-3A	1600	0.71	--	1.59	.18	--	--	0.73	6.80	0.69
322-3B	1600	(0.78)	2.0	1.52	--	--	--	--	--	--
322-5	2000	(0.86)	1.55	--	--	--	--	--	--	--
322-6	2000	(0.86)	1.41	--	--	--	--	--	--	--
322-10C	2100	(0.84)	1.8	--	--	--	--	--	--	--
322-11A	1670	0.74	--	1.49	.207	--	--	0.25	1.77	.59
322-11B	1670	0.72	1.9	--	.26	--	--	0.24	0.791	0.17
322-12A	1600	0.55	--	1.43	.28	--	--	0.24	2.23	0.24
322-12B	1600	0.73	--	1.50	.23	--	--	0.35	2.04	0.24
322-13A	1670	0.78	--	1.45	.17	--	--	0.59	4.06	--
322-14A	1670	(0.76)	1.74	--	--	--	--	--	--	--

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resis-tivity Ω-cm (×10)	Hard-ness (DPH)	Int. Frict. $(\times10^3)$	Sonic Mod. psi $(\times10^{-6})$	Compr. Str. psi $(\times10^{-3})$	Ult. Str. psi $(\times10^{-3})$
322-15B	1670	0.79	--	1.48	.19	--	--	0.57	6.82	--
322-16A	1670	(0.81)	1.89	--	--	--	--	--	--	--
322-16B	1670	0.78	--	1.54	.22	--	--	0.35	3.97	0.82
322-17B	1670	0.71	--	1.48	.37	--	--	0.2	--	0.37
322-18A	1670	1.07	--	1.49	.09	--	--	2.17	37.3	6.29
322-19A	1670	(0.85)	1.98	--	--	--	--	--	--	--
322-19B	1670	0.79	--	1.55	.28	--	--	0.33	4.16	0.41
322-20	1400	0.78	--	1.57	.17	--	--	0.77	8.97	1.43
322-21	1400	0.74	--	1.45	.22	--	--	0.53	3.34	0.74
322-22A	1400	(0.88)	--	1.48	--	--	--	--	4.1	1.19
322-22B	1400	(0.89)	--	1.49	--	--	--	--	5.2	1.19
322-23A	1400	(0.84)	--	1.47	--	--	--	--	--	--
322-23B	1300	(0.83)	--	1.61	--	--	--	--	--	4.07
322-24A	1300	(0.87)	--	1.51	--	--	--	--	--	1.28
322-24B	1400	(0.82)	--	1.59	--	--	--	--	--	1.28
322-25A	1410	0.82	--	1.48	.11	--	--	1.56	23.17	3.24
322-25A	1670	0.88	--	1.64	.13	--	--	1.48	19.68	2.17
322-26	1400	0.98	--	--	.11	--	--	2.04	27.15	3.6
322-27A	1400	0.83	--	1.42	.08	--	--	1.58	24.94	2.63
322-28A	1400	(0.93)	--	1.44	.10	--	--	--	18.4	3.16
322-29A	1400	0.66	--	1.46	.19	--	--	0.68	10.62	1.63
322-30	1410	0.85	1.64	1.42	.18	--	--	0.79	2.68	0.773
322-31B	1410	0.69	--	1.58	.34	--	--	0.24	1.85	0.363
322-32	1350	0.74	--	1.60	.24	--	--	0.36	3.06	0.465
322-33	1350	0.71	--	1.62	.22	--	--	0.60	2.775	1.32
322-34	1350	0.75	--	1.34	.13	--	--	1.07	13.43	3.85
322-35	1350	0.77	--	1.43	.22	--	--	0.68	11.8	1.33
322-36	1543	0.88	--	1.45	.10	--	--	1.29	23.0	3.74
322-37	1543	0.78	--	1.44	.20	--	--	0.47	3.697	1.178
322-38	1543	0.73	--	1.68	.17	--	--	0.93	11.16	2.47
322-39	1440	0.59	--	1.55	.18	--	--	0.72	10.1	2.94
322-40	1440	0.79	--	1.59	.11	--	--	1.14	13.95	3.45
322-41	1440	0.73	--	1.59	.17	--	--	0.84	9.83	2.597

Sample #	Temp.°C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resis-tivity Ω-cm (×10)	Hard-ness (DPH)	Int. Frict. (×10³)	Sonic Mod. psi (×10⁻⁶)	Compr. Str. psi (×10⁻³)	Ult. Str. psi (×10⁻³)
322-42A_3	1440	0.72	--	--	.14	--	--	0.88	10.77	2.97
322-42A_4	1440	0.64	--	--	.23	--	--	0.68	13.9	1.00
322-42B_1	1440	0.66	--	1.44	.20	--	--	0.69	9.89	1.96
322-42B_2	1440	0.75	--	1.46	.18	--	--	0.87	13.19	2.22
322-42B_3	1440	0.73	--	1.46	.27	--	--	0.89	19.4	3.11
322-42B_4	1440	0.66	--	1.51	.17	--	--	0.70	12.2	1.07
322-42B_5	1440	0.68	--	--	.19	--	--	0.76	14.45	2.50
322-42B_6	1440	0.75	--	1.49	.19	--	--	0.97	16.85	1.26
322-45	1440	0.82	--	1.72	.20	--	--	0.68	6.76	2.04
322-48	1605	0.68	--	1.48	.29	--	--	0.43	2.16	0.992
322-49A	1605	0.79	--	1.46	.15	--	--	0.79	13.2	2.24
322-50	1600	0.73	--	1.52	.15	--	--	0.56	7.11	1.38
322-51	1460	(0.78)	--	1.56	--	--	--	--	--	--
322-56	1500	(1.00)	--	1.53	--	--	--	--	--	--
322-56A	1500	(0.96)	--	1.33	--	--	--	--	--	--
322-57	1500	(1.06)	--	1.63	--	--	--	--	--	--
322-57A	1500	(1.03)	--	1.62	--	--	--	--	--	--
322-61	1500	0.74	--	1.46	.189	--	--	0.4	3.92	1.01
322-62	1500	0.96	--	1.49	.095	--	--	1.21	16.5	3.12
322-63	1500	1.00	--	1.56	.074	--	--	1.69	35.8	4.11
322-63A	1500	1.19	--	1.49	.057	--	--	2.47	24.3	5.13
322-64	1370	0.98	--	1.60	.076	--	--	1.92	45.6	5.41
322-64A	1370	(1.10)	--	1.51	--	--	--	--	--	--
322-64B	1370	0.93	--	1.61	.085	--	--	1.89	38.9	5.93
322-65	1370	(1.28)	--	1.43	--	--	--	--	--	--
322-66	1370	(1.09)	--	1.37	--	--	--	--	--	--
322-67	1350	0.85	--	1.64	.099	--	--	1.32	30.9	4.86
322-67A	1370	(0.84)	--	1.52	--	--	--	--	--	--
322-67B	1370	0.82	--	1.41	.101	--	--	1.33	27.9	4.48
322-68	1370	0.74	--	1.52	.180	--	--	0.53	7.6	1.47
322-68A	1370	(0.79)	--	1.25	.150	--	--	--	--	--
322-68B	1370	(0.77)	--	1.48	--	--	--	--	--	--
322-69	1370	0.69	--	1.50	.189	--	--	0.42	5.2	1.19

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resistivity Ω-cm (×10)	Hardness (DPH)	Int. Frict. ($\times 10^3$)	Sonic Mod. psi ($\times 10^{-6}$)	Compr. Str. psi ($\times 10^{-3}$)	Ult. Str. psi ($\times 10^{-3}$)
322-69A	1370	0.72	--	1.47	.198	--	--	0.42	5.1	1.38
322-70	1370	0.69	--	1.44	.224	--	--	0.38	6.09	1.14
323-1	1370	(1.01)	--	1.46	--	--	--	--	--	--
323-2	1370	0.78	--	1.45	.112	--	--	1.15	26.7	4.33
323-2A	1370	0.80	--	1.44	.111	--	--	1.30	26.5	4.1
323-3	1370	(0.98)	--	1.51	--	--	--	--	--	--
323-3A	1370	1.13	--	1.53	.061	--	--	2.48	48.5	6.51
323-4	1370	0.78	--	1.47	.176	--	--	0.55	8.6	1.88
323-4A	1370	0.78	--	1.47	.179	--	--	0.55	8.39	1.73
323-5	1000	0.74	--	1.50	.44	--	--	0.079	4.37	.82
323-5A	1000	0.72	--	1.46	.432	--	--	0.078	4.04	.94
323-6	1000	(0.92)	--	1.47	--	--	--	--	--	--
323-6A	1000	(0.91)	--	1.43	--	--	--	--	--	--
323-7	1000	(0.77)	--	1.51	--	--	--	--	--	--
323-7A	1000	0.77	--	1.50	.339	--	--	0.15	8.18	1.29
323-8	1000	(0.93)	--	1.51	--	--	--	--	--	--
323-8A	1000	1.0	--	1.52	.191	--	--	0.28	20.96	4.43
323-9	1000	1.03	--	1.51	.166	--	--	0.31	12.59	3.10
323-9A	1000	1.07	--	1.52	.179	--	--	0.14	12.75	1.83
323-11A	1000	(0.77)	--	1.50	--	--	--	--	--	--
323-11B	1000	0.77	--	1.49	.435	--	--	0.079	5.35	1.01
323-11C	1000	(0.73)	--	1.50	--	--	--	--	--	--
323-11D	1000	(0.71)	--	1.51	--	--	--	--	--	--
323-11E	1000	0.79	--	1.47	.406	--	--	--	5.38	1.83
323-11F	1000	0.74	--	1.52	.433	--	--	0.059	3.97	.84
323-11G	1000	(0.78)	--	1.52	--	--	--	--	--	--
323-12	1000	1.04	--	1.53	.19	--	--	0.24	10.63	2.1
323-12A	1000	1.06	--	1.51	.207	--	--	0.22	6.58	2.74
323-13	1000	1.12	--	1.53	.161	--	--	0.386	15.42	2.7
323-13A	1000	1.13	--	1.53	.157	--	--	0.387	16.00	2.51
323-14	1000	1.17	--	1.56	.123	--	--	--	17.00	3.12
323-15	1000	(0.97)	--	1.55	--	--	--	--	--	--
323-15A	1000	(0.95)	--	1.55	--	--	--	--	--	--

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resistivity Ω-cm (×10)	Hardness (DPH)	Int. Frict. ($\times 10^{3}$)	Sonic Mod. psi ($\times 10^{-6}$)	Compr. Str. psi ($\times 10^{-3}$)	Ult. Str. psi ($\times 10^{-3}$)
323-19	1000	0.6	--	1.50	.549	--	--	0.075	3.21	.67
323-20	1000	0.85	--	1.50	.172	--	--	0.28	31.6	4.08
323-20A	1000	0.82	--	1.50	.186	--	--	0.26	20.0	4.54
323-21	1000	0.92	--	1.42	.199	--	--	0.23	11.72	3.03
323-22	1000	0.86	--	1.49	.179	--	--	0.29	27.45	5.01
323-23	1000	0.9	--	1.37	.192	--	--	0.25	9.35	2.02
323-24	1000	(1.08)	--	1.59	--	--	--	--	--	--
323-25	1038	0.66	--	1.49	.583	--	--	0.034	3.4	.69
323-25A	1038	0.67	--	1.47	.444	--	--	0.036	3.1	.54
323-26	1038	0.88	--	1.47	.223	--	--	0.207	13.8	2.32
323-26A	1038	0.88	--	1.46	.228	--	--	0.198	12.3	2.43
323-26B	1038	(0.94)	--	1.57	--	--	--	--	--	--
323-27	1038	0.94	--	1.45	.492	--	--	--	12.6	2.88
323-27A	1038	(0.89)	--	1.45	--	--	--	--	--	--
323-28	1038	0.93	--	1.43	.223	--	--	0.207	--	--
323-28A	1038	0.92	--	1.44	.267	--	--	0.18	8.71	1.59
323-29	1038	0.64	--	1.47	.705	--	--	--	3.64	.31
323-29A	1038	(1.19)	--	1.47	--	--	--	--	--	--
323-30A	1000	--	--	1.53	--	--	--	--	--	--
323-30B	1000	(1.18)	--	1.53	--	--	--	--	--	--
323-30C	1000	--	--	1.54	--	--	--	--	--	--
323-31	1038	0.82	--	1.36	.204	--	--	--	9.21	2.05
323-32	1038	0.92	--	1.46	.233	--	--	0.199	10.4	2.5
323-32A	1038	0.92	--	1.45	.226	--	--	0.21	--	2.77
323-32B	1038	--	--	1.42	--	--	--	--	--	--
323-32C	1038	--	--	1.45	--	--	--	--	--	--
323-32D	1038	--	--	1.44	--	--	--	--	--	--
323-33	1027	(0.79)	--	1.45	--	--	--	--	--	--
323-34	1038	1.06	--	1.45	.156	--	--	--	11.68	2.59
323-35	1027	(0.82)	--	1.48	--	--	--	--	--	--
323-35A	1082	0.9	--	1.44	.23	--	--	0.23	10.3	2.24
323-36	1027	0.71	--	1.5	--	--	--	--	--	--

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resistivity Ω-cm (×10)	Hardness (DPH)	Int. Frict. ($\times 10^3$)	Sonic Mod. psi ($\times 10^{-6}$)	Compr. Str. psi ($\times 10^{-3}$)	Ult. Str. psi ($\times 10^{-3}$)
323-36A	1082	0.68	--	1.473	.395	--	--	0.081	5.52	2.53
323-38	1027	0.86	--	1.5	.24	--	--	0.188	11.2	2.5
323-38B	1082	0.9	--	1.53	.211	--	--	--	10.8	2.6
323-39	1082	0.99	--	1.44	.169	--	--	0.311	13.9	2.44
323-40	1027	0.98	--	1.47	.2	--	--	0.208	11.9	2.34
323-41	1027	0.84	--	1.49	.26	--	--	--	3.96	1.62
323-42	1082	0.9	--	--	.212	--	--	--	4.2	2.14
323-43	1027	0.88	--	1.48	.23	--	--	--	9.5	1.1
323-45	1027	0.82	--	1.50	.28	--	--	0.15	7.3	2.12
323-46	1027	0.87	--	1.51	.24	--	--	0.187	10.6	2.67
323-47	1027	0.91	--	1.48	.21	--	--	--	9.35	3.35
323-48	1027	0.87	--	1.50	.23	--	--	0.20	11.2	2.7
323-49	1027	0.90	--	--	.228	--	--	0.25	11.66	.94
323-50	1027	0.92	--	1.51	.15	--	--	0.29	35.6	4.58
323-51	1027	--	--	1.55	--	--	--	--	--	--
323-52	1027	--	--	1.45	--	--	--	--	--	--
323-54	1082	0.9	--	1.45	.184	--	--	--	10.02	1.83
323-55	1027	0.87	--	1.48	.22	--	--	0.20	12.1	1.28
323-56	1082	0.98	--	1.45	.153	--	--	--	15.3	--
323-57	1027	0.8	--	1.54	.25	--	--	0.175	9.11	1.48
323-58	1027	0.73	--	1.54	.33	--	--	0.114	6.8	1.85
323-62	1027	--	--	1.51	--	--	--	--	--	--
323-65	1027	0.92	--	1.48	.21	--	--	0.199	10.8	2.64
323-66	1027	0.90	--	1.49	.23	--	--	0.21	7.95	2.49
323-67	1000	0.97	--	1.45	.13	--	--	0.43	41.7	7.35
323-68	1000	0.82	--	1.52	.3	--	--	--	7.43	1.88
323-69	1000	0.86	--	1.49	.22	--	--	0.173	7.71	2.18
324-1	1000	0.78	--	1.49	.29	--	--	0.128	5.9	1.68
324-2	1000	0.79	--	1.45	.28	--	--	0.162	6.38	1.33
324-3	1000	0.80	--	1.52	.24	--	--	0.179	8.72	2.29
324-4	1000	0.99	--	1.52	.14	--	--	0.39	25.2	4.87
324-5	1000	0.75	--	1.52	.29	--	--	0.12	6.73	1.99
324-6	1000	0.78	--	1.53	.295	--	--	0.13	7.04	2.54

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	He	ρ_{real} (g/cc) Xyl	Resis-tivity Ω-cm (×10)	Hard-ness (DPH)	Int. Frict. $(\times 10^3)$	Sonic Mod. psi $(\times 10^{-6})$	Compr. Str. psi $(\times 10^{-3})$	Ult. Str. psi $(\times 10^{-3})$
324-7	1000	0.78	--	1.48	.305	--	--	0.13	7.43	2.28
324-8	1000	0.78	--	1.52	.285	--	--	0.137	7.6	2.19
324-9	1000	0.80	--	1.53	.28	--	--	--	7.21	2.16
324-10	1000	--	--	1.50	--	--	--	--	--	--
324-11	1000	0.94	--	1.53	.14	--	--	0.305	27.4	4.15
324-12	1000	0.86	--	--	.19	--	--	0.25	18.0	3.02
324-13	1000	0.97	--	1.50	.14	--	--	0.337	32.9	5.37
324-14	850	1.07	--	1.41	.110	--	--	--	--	--
324-14	1066	1.09	--	1.42	.114	--	--	0.50	46.9	7.59
324-15	1066	0.96	--	1.48	.15	--	--	0.242	16.13	3.49
324-16	1066	1.0	--	1.47	.12	--	--	0.37	30.22	4.6
324-18	1066	0.99	--	1.56	.127	--	--	0.43	42.20	6.25
324-19	1066	0.83	--	1.54	.215	--	--	0.189	14.88	2.41
324-20	1066	0.84	--	1.49	.249	--	--	0.162	14.47	1.99
324-21	1066	1.04	--	1.49	.117	--	--	0.486	46.03	5.0
324-21A	1066	1.03	--	1.48	.127	--	--	0.46	37.00	4.9
324-22	1066	0.9	--	1.55	.185	--	--	--	23.37	3.74
324-23	1066	0.97	--	1.52	.2	--	--	0.295	14.39	2.33
324-24	1066	0.99	--	1.55	.183	--	--	0.256	15.73	2.4
324-25A	1066	0.84	--	1.42	.17	--	--	0.275	28.32	4.0
324-25B	1066	0.75	--	1.49	.537	--	--	0.039	2.99	.42
324-25C	1066	0.74	--	1.5	.382	--	--	0.089	3.82	.46
324-25D	1060	0.91	--	--	.165	--	--	--	22.99	4.84
324-26	1066	1.0	--	1.54	.119	--	--	0.46	44.83	5.7
324-27A	1060	0.71	--	1.53	.291	--	--	0.089	5.05	.95
324-27B	1060	0.5	--	1.56	1.102	--	--	0.007	.459	.12
324-27C	1060	0.5	--	1.54	1.472	--	--	--	.459	.10
324-27D	1060	0.52	--	1.53	1.116	--	--	--	.391	--
324-28	1060	--	--	1.54	--	--	--	--	--	--
324-29	1060	0.8	--	1.44	.269	--	--	0.105	3.11	.76
324-30	1060	--	--	1.60	--	--	--	--	--	--
324-31	1060	--	--	1.40	--	--	--	--	--	--
324-32	1060	0.93	--	1.54	.25	--	--	0.15	5.20	1.93

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resistivity Ω-cm ($\times 10$)	Hardness (DPH)	Int. Frict. ($\times 10^{3}$)	Sonic Mod. psi ($\times 10^{-6}$)	Compr. Str. psi ($\times 10^{-3}$)	Ult. Str. psi ($\times 10^{-3}$)
324-33	1060	0.82	--	1.50	.165	--	--	0.234	23.3	3.5
324-34	1060	1.02	--	1.57	.134	--	--	0.31	22.2	4.04
324-35	1060	0.97	--	1.56	.204	--	--	0.20	9.59	2.03
324-36	1060	(0.872)	--	1.54	--	--	--	--	--	--
324-37	1060	0.87	--	1.46	.206	--	--	0.19	7.20	1.83
324-38	1066	0.88	--	1.49	.232	--	--	--	9.11	1.94
324-39	1066	0.88	--	1.51	.278	--	--	0.17	7.91	1.99
324-40	1066	--	--	1.55	--	--	--	--	--	--
324-40D	1066	0.92	--	--	.185	--	--	0.20	9.08	2.12
324-40E	1066	0.89	--	1.43	.198	--	--	0.21	5.84	1.57
324-40A	1066	0.89	--	1.53	.277	--	--	0.105	4.28	1.02
324-41	1066	0.89	--	1.50	.219	--	--	0.19	10.1	2.34
324-42	1066	0.88	--	1.48	.203	--	--	0.18	6.07	2.06
324-43	1066	0.96	--	1.54	.173	--	--	0.265	11.6	3.37
324-44	1066	0.91	--	1.51	.204	--	--	0.17	11.9	2.08
324-45	1066	0.92	--	1.52	.183	--	--	0.27	12.0	3.47
324-46	1066	0.87	--	1.59	.184	--	--	0.20	6.98	2.41
324-47	1066	0.94	--	1.50	.208	--	--	0.17	6.12	1.53
324-48	1066	0.92	--	1.59	.195	--	--	0.20	9.7	2.47
324-49	1104	(0.78)	--	1.55	--	--	--	--	--	--
324-51	1104	1.11	--	1.54	.111	--	--	0.55	37.65	6.40
324-52	1104	1.0	--	1.50	.187	--	--	0.22	9.64	2.10
324-54	1066	(0.97)	--	1.59	--	--	--	--	--	--
324-56	1066	0.98	--	1.43	.202	--	--	0.20	8.77	2.63
324-57	1066	1.04	--	1.46	.135	--	--	0.45	21.5	--
324-58	1066	0.95	--	1.53	.183	--	--	0.29	8.36	2.17
324-59	1066	(0.78)	--	1.52	--	--	--	--	--	--
324-61	1066	1.04	--	1.45	.129	--	--	0.41	12.44	3.49
324-62	1066	0.98	--	1.47	.19	--	--	0.24	9.0	2.54
324-63	1066	0.95	--	1.51	.214	--	--	0.26	9.88	1.95
324-64	1066	(0.69)	--	1.56	--	--	--	--	--	--
324-65	1066	0.81	--	1.59	.267	--	--	0.13	6.81	--
324-66	1066	0.70	--	1.56	.347	--	--	0.066	3.36	.78

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resistivity Ω-cm (×10)	Hardness (DPH)	Int. Frict. ($\times 10^3$)	Sonic Mod. psi ($\times 10^{-6}$)	Compr. Str. psi ($\times 10^{-3}$)	Ult. Str. psi ($\times 10^{-3}$)
324-67	1066	0.90	--	1.59	.251	--	--	0.14	8.62	1.76
324-68	1066	(0.81)	--	1.59	--	--	--	--	--	--
324-69	1066	0.78	--	1.52	.284	--	--	0.12	6.39	1.31
324-70	1066	0.79	--	1.55	.274	--	--	0.12	6.40	1.46
324-71	1066	0.91	--	1.54	.229	--	--	0.17	7.98	--
324-72	1066	0.72	--	1.55	.351	--	--	0.06	2.64	.54
325-1	1066	0.88	--	1.52	.163	--	--	0.30	31.09	3.55
325-2	1066	--	--	1.48	--	--	--	--	--	--
325-2A	1066	(0.91)	--	1.51	--	--	--	--	--	--
325-2C	1066	(0.87)	--	1.53	--	--	--	--	--	--
325-2D	1066	(0.83)	--	1.5	--	--	--	--	--	--
325-2E	1066	(0.82)	--	1.5	--	--	--	--	--	--
325-3	1066	--	--	1.49	--	--	--	--	--	--
325-5	1066	0.885	--	1.54	.260	--	--	--	8.14	1.58
325-6	1066	1.080	--	1.4	.234	--	--	--	38.97	6.89
325-7	1066	0.939	--	1.53	.138	--	--	--	11.33	2.83
325-8	1066	(0.72)	--	1.51	--	--	--	--	--	--
325-9	1066	(0.85)	--	1.57	--	--	--	--	--	--
325-10C	1066	0.852	--	1.52	.388	--	--	--	7.73	1.78
325-11	1066	0.761	--	1.54	.411	--	--	--	--	--
325-12	1066	0.784	--	1.66	.304	--	--	--	--	--
325-13	1066	0.820	--	1.47	.180	--	--	--	--	--
325-14	1066	0.912	--	1.49	.174	--	--	--	--	--
325-15	1066	--	--	1.56	--	--	--	--	--	--
325-16	1066	(0.77)	--	1.52	--	--	--	--	--	--
325-17	1066	--	--	1.44	--	--	--	--	--	--
325-18A	1066	0.747	--	--	.153	--	--	--	--	--
325-18B	1066	0.729	--	--	.315	--	--	--	--	--
325-18C	1066	0.769	--	--	.313	--	--	--	--	--
325-19A	1066	0.705	--	--	.321	--	--	--	--	--
325-19B	1066	0.730	--	--	.311	--	--	--	--	--
325-19C	1066	0.715	--	--	.283	--	--	--	--	--
325-20	1066	0.725	--	1.65	.369	--	--	--	7.32	1.49

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resis-tivity Ω-cm (×10)	Hard-ness (DPH)	Int. Frict. $(\times10^{3})$	Sonic Mod. psi $(\times10^{-6})$	Compr. Str. psi $(\times10^{-3})$	Ult. Str. psi $(\times10^{-3})$
325-21	1066	0.807	--	1.54	.274	--	--	--	--	--
325-22	1066	0.868	--	1.60	.224	--	--	--	--	--
325-23	1060	0.848	--	1.55	.244	--	--	--	--	--
325-24	1060	0.830	--	1.59	.243	--	--	--	--	--
325-25	1060	(0.72)	--	1.60	--	--	--	--	--	--
325-26	1060	1.017	--	1.57	.285	--	--	--	--	--
325-27	1060	(0.93)	--	1.59	--	--	--	--	--	--
325-28	1066	0.844	--	1.61	.315	--	--	--	8.56	1.98
325-29	1066	(0.54)	--	1.51	--	--	--	--	--	--
325-30	1066	(0.80)	--	1.51	--	--	--	--	--	--
325-31	1066	0.768	--	1.45	.256	--	--	--	--	--
325-32	1066	0.791	--	1.52	.273	--	--	--	--	--
325-33	1066	0.878	--	1.51	.252	--	--	--	--	--
325-34	1066	(0.82)	--	1.45	--	--	--	--	--	--
325-35	1066	0.896	--	1.54	.320	--	--	--	7.47	1.70
325-36	1066	0.952	--	1.49	.239	--	--	--	--	--
325-37	1066	(0.81)	--	1.47	--	--	--	--	--	--
325-38	1066	0.839	--	1.53	.329	--	--	--	--	--
325-39	1066	0.907	--	1.50	.271	--	--	--	--	--
325-41	1066	0.766	--	1.51	.343	--	--	--	--	--
325-42	1066	0.802	--	1.53	.358	--	--	--	7.69	1.26
325-43	1066	0.772	--	1.59	.406	--	--	--	5.32	1.23
325-44	1066	0.724	--	1.54	.264	--	--	--	--	--
325-45	1066	0.817	--	1.51	.291	--	--	--	4.49	1.06
325-46	1066	(0.82)	--	1.54	--	--	--	--	--	--
325-47	1066	0.864	--	1.57	.270	--	--	--	--	--
325-48	1066	0.740	--	1.52	.383	--	--	--	5.25	1.16
325-49	1066	(0.85)	--	1.52	--	--	--	--	--	--
325-50	1066	0.864	--	1.58	.251	--	--	--	--	--
325-51	1066	0.897	--	1.56	.273	--	--	--	--	--
325-52	1066	(0.77)	--	1.54	--	--	--	--	--	--
325-53A	1066	(0.97)	--	1.51	--	--	--	--	--	--
325-54	1066	0.841	--	1.60	.285	--	--	--	6.4	1.3

Sample #	Temp. °C	$\rho_{app.}$ (g/cc)	ρ_{real} (g/cc) He	ρ_{real} (g/cc) Xyl	Resis-tivity Ω-cm (×10)	Hard-ness (DPH)	Int. Frict. ($\times 10^{3}$)	Sonic Mod. psi ($\times 10^{-6}$)	Compr. Str. psi ($\times 10^{-3}$)	Ult. Str. psi ($\times 10^{-3}$)
325-55	1066	0.937	--	1.54	.211	--	--	--	14.94	2.9
325-55A	1066	0.708	--	1.46	.231	--	--	--	4.79	1.15
325-56	1066	0.984	--	1.48	.151	--	--	--	22.6	4.25
325-57	1060	0.853	--	1.57	.268	--	--	--	7.25	1.60
325-57A	1060	0.837	--	1.55	.277	--	--	--	8.67	1.62
325-58	1060	0.873	--	1.52	.301	--	--	--	5.5	1.25
325-58A	1066	0.839	--	1.52	.295	--	--	--	7.85	1.76
325-59	1066	0.696	--	1.52	.273	--	--	--	2.47	.54
325-59A	1066	0.719	--	1.60	.264	--	--	--	2.52	.65
325-59B	1066	0.815	--	1.50	.254	--	--	--	8.32	1.83
325-59C	1066	0.835	--	1.46	.247	--	--	--	10.98	1.81
325-60	1066	0.919	--	1.51	.250	--	--	--	9.01	1.85
325-60A/W	1066	0.864	--	1.52	.316	--	--	--	5.26	1.23
325-61	1066	0.919	--	1.50	.239	--	--	--	10.1	2.42
325-61A	1066	0.823	--	1.51	.252	--	--	--	7.06	1.95
325-61B	1066	0.867	--	1.48	.222	--	--	--	8.89	2.05
325-61C	1066	0.820	--	1.47	.282	--	--	--	5.9	1.31
325-61D	1082	0.838	--	1.44	.308	--	--	--	--	--
325-61E	1082	0.834	--	1.49	.282	--	--	--	--	--
325-62	1082	0.879	--	1.52	.221	--	--	--	--	--
325-62A	1082	0.877	--	1.51	.237	--	--	--	--	--
325-62B	1082	0.966	--	1.50	.179	--	--	--	--	--

TABLE 10 Physical Properties Correlated with Density

Sample #	$E_s/\rho_{app.}$ in($\times10^{-6}$)	$\sigma_{cs}/\rho_{app.}$ in($\times10^{-3}$)	$\sigma_{UTS}/\rho_{app.}$ in($\times10^{-3}$)	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times10^{-6}$)	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times10^{-3}$)	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times10^{-3}$)	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm($\times10$)
310-35	--	252.4	49.2	--	18.8	3.67	--
311-34	--	333.3	325.9	--	--	--	--
311-35	19.2	37.2	66.9	--	--	--	--
312-13	--	1298.0	125.9	--	--	--	--
312-14	--	1000.0	--	--	51.8*	--	--
312-16	--	62.2	102.1	--	3.26	5.33	--
312-27	--	--	188.0	--	--	--	--
312-29	--	1030.6	--	--	56.4*	--	--
312-32	--	901.2	158.3	--	47.7*	8.38*	--
312-34	--	824.2	33.5	--	40.9*	1.09*	--
312-49	--	--	150.5	--	--	7.86	--
315-2	50.3	58.5	14.3	2.76*	3.2*	0.78*	.016*
315-14	--	1235.5	136.0	--	71.2*	1.04*	--
315-17	--	1030.0	88.3	--	--	--	--
315-20A	48.8	--	--	2.82*	--	--	--
315-20B	49.3	--	--	2.85*	--	--	.013*
315-20C	48.1	--	--	2.76*	--	--	.009*
315-21B	--	--	191.0	--	--	10.45	--
315-21C	45.8	1428.6	217.6	2.51*	78.2*	11.9*	.009*
315-21D	--	743.0	209.5	--	40.6	11.47	--
315-25A	--	767.0	145.5	--	38.9	7.39	--
315-25B	--	--	152.6	--	--	7.75	--
315-25C	48.8	1120.5	232.9	2.41*	56.9*	11.8*	.020*
315-26B	--	962.8	209.3	--	50.3	10.92	--
315-26C	41.7	888.9	147.2	2.18*	46.4*	7.7*	.003*
315-26D	46.2	1224.9	--	2.34*	63.9*	--	.009*
315-28	--	1079.3	127.0	--	56.7*	6.68*	--
315-31B	50.0	1218.8	178.8	2.63*	63.4*	9.4*	.007*
315-31C	49.3	--	--	2.63*	--	--	.015*
315-31D	48.8	1105.0	201.5	2.56*	58.1*	10.6*	.014*
315-32	--	1262.6	178.2	--	65.0*	9.2*	--

*Calculated with helium (otherwise with xylene).

Sample #	$E_s/\rho_{app.}$ in($\times 10^{-6}$)	$\sigma_{cs}/\rho_{app.}$ in($\times 10^{-3}$)	$\sigma_{UTS}/\rho_{app.}$ in($\times 10^{-3}$)	$I_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-6}$)	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-3}$)	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-3}$)	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm($\times 10$)
315-33	44.9	--	--	2.42*	--	--	.010*
315-34C	40.3	972.2	136.6	2.29*	55.3*	7.7*	.011*
315-34D	51.5	690.2	114.9	2.91*	39.0*	6.5*	.006*
315-37	31.9	744.2	131.6	1.70	39.7	7.01	.009
315-38A	35.9	925.9	114.6	1.95*	50.3*	6.2*	.011*
315-39A	51.5	1038.8	161.7	2.65	53.5	8.33	.013
315-39B	51.0	824.7	127.6	2.62	42.5	6.57	.002
315-41	--	612.8	--	--	31.1	--	.001
315-41A	48.7	671.0	72.2	2.93*	40.3*	4.3*	.002*
315-41B	45.9	563.0	69.9	2.69	33.8*	4.3*	.007*
315-42	52.7	--	--	2.79	--	--	.015
315-43	--	1335.5	--	--	71.1	--	--
315-44	52.1	--	--	2.69	--	--	.011
315-45B	211.9	--	--	12.74	--	--	.002
315-46A	--	2.78	2.48	--	4.4*	3.9*	--
317-1	--	1297.1	172.2	--	56.1	7.5	--
317-2	35.6	922.0	116.2	1.85	48.4	6.07	.009
317-5	--	1175.0	266.0	--	55.6	12.6	--
317-8	50.4	1120.9	63.4	2.62	57.6	3.30	--
317-9	--	964.8	172.3	--	61.1*	10.9*	--
317-10	50.9	1536.6	210.9	2.61*	78.5*	10.8*	.001*
317-12	--	--	181.6	--	--	10.5*	--
317-14	--	874.8	149.7	--	46.9*	8.03*	--
317-15	--	1025.6	124.8	--	53.9*	6.6*	--
317-18	33.0	126.0	104.0	1.51	8.93	5.78	.005
317-19	--	693.2	215.1	--	41.9*	13.0*	--
317-23	--	254.0	63.4	--	13.4	3.34	--
317-24	52.9	1794.6	159.7	2.99*	101.4*	9.0*	.009*
317-25	--	1076.4	89.9	--	54.6	4.57	--
317-26	53.7	167.4	32.8	2.86*	8.9*	1.7*	.010*
317-29	32.3	615.0	92.8	1.73	33.0	4.99	.006
317-32	51.3	1380.0	113.0	2.63	71.0	8.11	.014
317-33	--	1092.0	152.0	--	57.5*	8.0*	--

Sample #	$E_s/\rho_{app.}$ in($\times 10^{-6}$)	$\sigma_{cs}/\rho_{app.}$ in($\times 10^{-3}$)	$\sigma_{UTS}/\rho_{app.}$ in($\times 10^{-3}$)	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-6}$)	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-3}$)	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-3}$)	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm($\times 10$)
317-34	88.4	1025.6	197.0	4.78	55.4	10.6	.014
317-37	49.8	1049.0	212.0	2.56	64.5	10.9	.014
317-38	31.1	1156.0	129.0	1.60	59.7	6.67	.017
317-39	43.3	963.0	129.0	1.98*	44.0*	5.9*	.002*
317-40	40.7	742.0	112.0	2.16*	39.4*	5.95*	.011*
317-41	--	298.0	70.0	--	17.1	4.0	--
317-41A	--	228.0	58.8	--	11.3	2.9	--
317-41B	--	668.0	96.5	--	35.7*	5.15*	--
317-42	49.1	1266.0	169.0	2.63*	66.3*	8.8*	.008*
317-43	--	462.0	76.0	--	23.4*	3.84*	--
317-44	44.6	903.0	70.4	2.43*	49.1*	3.83*	.0004*
317-45	--	1017.0	164.0	--	51.4*	8.3*	--
317-46	43.5	1183.0	215.0	2.32*	63.2*	9.7*	.006*
317-47	--	785.0	160.0	--	39.3*	8.05*	--
317-48	29.9	--	--	1.57*	--	--	--
317-49	30.8	385.4	104.2	1.67*	20.9*	5.7*	.018*
318-1	24.8	--	89.8	1.35*	--	4.9*	.009*
318-2C	25.0	1076.8	148.9	--	--	--	--
318-7	23.2	29.2	28.0	1.12	1.41	2.87	--
318-8	--	526.6	162.6	--	28.2*	8.7*	--
318-8A	--	936.4	--	--	50.23	--	--
318-9	--	792.8	150.2	--	42.8*	8.1*	--
318-11	45.3	--	155.0	2.58*	--	8.8*	--
318-14	14.6	170.9	29.9	.76*	9.0*	1.6*	.015*
318-16	42.3	831.0	118.0	2.26*	44.4*	2.3*	.017*
318-17	44.2	1246.2	163.0	2.66*	65.5*	8.51*	.019*
318-22	43.2	987.0	146.0	2.25*	51.5*	7.63*	.014*
318-24	42.5	--	--	2.35	--	--	--
318-24C	--	752.0	134.0	--	33.6	6.01	--
318-28	43.9	--	--	2.30*	--	--	.010*
318-29	--	10.1	32.2	--	.5*	1.7*	.008*
318-30	39.2	563.3	149.62	2.10*	30.2*	8.03*	--
318-31	6.8	80.3	9.6	0.33	3.96	0.47	.009

Sample #	$E_s/\rho_{app.}$ in($\times 10^{-6}$)	$\sigma_{cs}/\rho_{app.}$ in($\times 10^{-3}$)	$\sigma_{UTS}/\rho_{app.}$ in($\times 10^{-3}$)	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-6}$)	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-3}$)	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-3}$)	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm($\times 10$)
318-32	--	650.0	--	--	36.5*	--	--
318-33	46.9	1118.1	164.9	2.62	61.6	9.1	.053
318-34	--	742.0	125.0	--	38.9*	6.57*	--
318-35	46.9	831.0	144.0	2.41*	42.9*	7.4*	.070*
318-36	36.6	505.0	90.6	1.87*	25.7*	4.62*	.008*
318-37	65.7	773.0	117.0	3.50*	41.3*	6.3*	.007*
318-39	67.3	785.0	179.0	3.82*	44.5*	10.1*	.007*
318-45	67.6	--	--	3.34	--	--	.006
318-46	62.7	1149.0	200.0	3.35	60.5	10.5	.029
318-48	--	89.7	212.0	--	4.63*	10.95*	--
318-51	26.0	546.0	45.3	4.23*	28.2*	2.3*	--
318-52	46.2	486.8	69.9	2.35*	24.7*	3.55*	.093*
318-53	--	151.0	51.1	--	7.9*	2.7*	--
318-58	2.8	--	165.0	.15	--	9.3	.154
318-59	60.1	886.0	117.0	3.00	44.2	5.9	--
318-60	52.0	1055.0	222.0	2.7	54.1	11.4	.010
318-61	40.4	620.0	109.0	2.00	30.9	5.4	.029
318-62	--	1195.0	201.0	--	60.2*	10.1*	--
321-3	--	1130.0	203.0	--	64.1*	11.5*	.021*
312-6	59.5	1061.0	210.0	3.43*	61.3*	12.1*	.021*
321-8	45.6	1197.0	215.0	2.39*	63.1*	11.4*	.034*
321-9	--	1283.0	231.0	--	59.3	10.7	--
321-10	66.0	1207.0	238.0	3.18*	58.4*	11.5*	.009*
321-11	44.9	1184.0	151.0	2.36*	60.9*	7.77*	.076*
321-12	35.0	427.0	72.0	1.67*	20.3*	3.4*	.089*
321-13	48.7	1032.0	176.0	2.64	57.2	9.54	.007
321-15	--	994.00	173.0	--	56.1*	9.7*	--
321-16A	50.7	792.0	148.0	3.36*	52.6*	9.8*	--
321-17B	53.5	1089.0	155.0	2.71*	55.1*	7.9*	--
321-18B	80.1	1726.0	246.0	4.02	92.2	13.2	--
321-19A	58.4	1006.0	193.0	2.99	51.4	9.9	--
321-19B	49.9	1055.0	192.0	2.62	55.2	10.1	--
321-20B	--	1381.0	246.4	--	74.6*	13.3*	--

Sample #	$E_s/\rho_{app.}$ in($\times10^{-6}$)	$\sigma_{cs}/\rho_{app.}$ in($\times10^{-3}$)	$\sigma_{UTS}/\rho_{app.}$ in($\times10^{-3}$)	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times10^{-6}$)	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times10^{-3}$)	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times10^{-3}$)	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm($\times10$)
321-21A	48.8	1344.6	187.6	2.54	70.2	9.8	.013
321-21B	53.6	1288.9	171.1	2.83	68.2	9.1	.014
321-22A	42.6	943.0	181.0	2.21	48.9	9.4	.018
321-22B	--	986.4	129.8	--	54.7	7.19	--
321-22C	42.6	1074.4	129.5	2.31	58.2	7.02	.011
321-22D4	42.7	1013.9	154.9	2.27	53.8	8.23	.012
321-23	54.8	1565.0	194.0	3.4*	93.0*	12.2*	.008*
321-23A	47.5	1183.4	184.0	2.61	65.2	10.1	.017
321-23B	48.4	1222.8	171.0	2.51	63.4	8.88	.012
321-24	52.9	1297.1	173.0	3.06	74.9	10.0	.012
321-24A	30.6	1430.5	205.1	1.6	75.5	10.8	.009
321-24B	57.6	1170.8	175.5	3.1	62.4	9.4	.011
321-25A	26.9	1103.0	213.5	1.41	58.2	11.2	.006
321-26	--	1466.7	42.8	--	82.4	2.4	--
321-27	20.0	313.3	43.3	1.2*	17.1*	2.4*	.006*
321-29	46.0	1157.0	172.0	2.81	59.2	8.79	.012
321-31F	26.0	503.8	82.6	1.6	30.5	5.0	.052
321-31G	--	599.0	95.2	--	36.0*	5.7*	.011*
321-31J	34.9	687.0	121.0	1.87	36.8	6.5	.010
321-31P	36.1	777.0	111.9	1.63	35.1	5.1	.017
321-31Q	46.3	1143.8	175.9	2.56	63.2	9.73	.011
321-31R	27.0	388.0	58.9	1.45	20.8	3.15	.011
321-31S	44.1	1063.9	160.9	2.22	53.4	8.08	.012
321-32A	26.9	1049.0	111.7	1.45	56.6	6.03	.011
321-32B	27.4	1098.2	171.4	1.50	60.3	9.41	.012
321-32C	27.98	1245.5	183.8	1.52	67.5	9.96	.013
321-32D	44.8	--	--	2.38	--	--	.016
321-32D1	6.59	--	--	0.35	--	--	.017
321-32E	45.9	1233.7	173.4	2.21*	59.28*	8.33*	.017*
321-32F	26.3	963.5	123.8	1.46	53.4	6.87	--
321-32G	45.45	926.5	131.98	--	--	--	--
321-33A	--	1171.9	175.5	--	59.7*	8.94*	.011*
321-33B	46.3	1666.9	208.0	2.46	88.53	11.05	.02

Sample #	$E_s/\rho_{app.}$ in($\times10^{-6}$)	$\sigma_{cs}/\rho_{app.}$ in($\times10^{-3}$)	$\sigma_{UTS}/\rho_{app.}$ in($\times10^{-3}$)	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times10^{-6}$)	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times10^{-3}$)	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times10^{-3}$)	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm(×10)
321-34A	42.96	902.4	217.7	2.47*	51.8*	12.5*	.016*
321-34B	86.56	980.5	85.98	4.97	56.3	4.94	.011
321-34D	42.54	--	--	2.29	--	--	--
321-34E$_1$	26.8	1191.6	158.2	1.17*	52.1*	6.92*	.0298*
321-36A	--	--	61.3	--	--	3.19	--
321-36B	29.7	1303.7	187.0	1.45	63.6	9.12	.023
321-37B	17.6	231.9	45.7	0.955*	12.57*	2.48*	.0106*
321-37E	32.9	48.7	12.6	2.09	3.1	.802	.0198
321-37F	3.4	44.7	9.37	.192	2.52	.528	--
321-37Q	7.8	65.1	15.6	.46	3.8	.9	.014
321-39	23.7	224.1	43.2	1.37*	13.0*	2.5*	.012*
321-40	--	23.0	2.8	--	1.18*	.14*	.013*
321-42A	12.6	73.9	20.6	.65	3.83	1.07	.012
321-42B	8.5	48.7	17.9	4.6*	2.6*	.96*	.012*
321-43A	22.7	49.7	14.0	1.3*	2.8*	.79*	.017*
321-43B	4.5	33.1	9.1	.24*	1.7*	.47*	.019*
321-46B	5.4	69.1	16.6	.28*	3.6*	.85*	.015*
321-48B	11.4	88.7	20.0	.6*	4.6*	1.0*	.014*
321-50B	40.8	769.9	123.0	2.1*	39.5*	6.3*	.011*
321-51	20.5	255.0	38.2	1.1*	13.8*	2.1*	--
321-51A	--	--	--	--	--	--	.013*
322-1A	9.11	135.0	26.2	.52	7.76	1.5	.012
322-1B	8.67	--	--	.62*	--	--	.016*
322-3A	28.5	265.1	26.9	1.63	15.2	1.55	.008
322-11A	9.4	66.2	22.07	.50	3.56	1.19	.010
322-11B	9.23	30.4	6.5	.63*	2.09*	.45*	.010*
322-12A	12.1	112.2	12.1	.62	5.80	.62	.011
322-12B	13.3	77.3	9.1	.72	4.2	.49	.011
322-13A	20.9	144.0	--	1.1	7.55	--	.009
322-15B	19.9	238.9	--	1.07	12.8	--	.010
322-16B	12.4	140.9	29.1	.69	7.84	1.62	.011
322-17B	7.8	--	14.4	.42	--	.77	.018
322-18A	56.1	964.8	162.7	3.02	51.9	8.76	.006
321-45B	10.9	1083.6	155.0	.59*	58.7*	8.39*	.007*

Sample #	$E_s/\rho_{app.}$ in($\times 10^{-6}$)	$\sigma_{cs}/\rho_{app.}$ in($\times 10^{-3}$)	$\sigma_{UTS}/\rho_{app.}$ in($\times 10^{-3}$)	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-6}$)	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-3}$)	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-3}$)	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm($\times 10$)
322-19B	11.[illegible]5	145.75	14.4	.65	8.16	.804	.014
322-20	27.[illegible]	317.6	50.7	1.55	18.0	2.88	.008
322-21	19.8	124.9	27.7	1.04	6.54	1.45	.011
322-22A	--	129.0	37.4	--	6.9	2.0	--
322-22B	--	161.7	37.0	--	8.71	1.99	--
322-23B	--	--	135.7	--	--	7.895	--
322-24A	--	--	40.7	--	--	2.22	--
322-24B	--	--	43.2	--	--	2.48	--
322-25A	52.7	782.0	109.4	2.82	41.8	5.85	.006
322-25A	46.6	619.0	68.25	2.76	36.7	4.04	.007
322-26	57.6	766.8	101.7	--	--	--	--
322-27A	52.7	831.7	87.7	2.7	42.7	4.5	.005
322-28A	--	547.6	94.0	--	28.5	4.89	.006
322-29A	28.5	445.4	68.36	1.5	23.5	3.6	.009
322-30	25.7	87.3	27.17	1.32	4.48	1.29	.011
322-31B	9.63	74.2	14.56	.55	4.24	.831	.015
322-32	13.5	114.5	17.4	.78	6.62	1.005	.011
322-33	23.4	108.2	51.46	1.37	6.33	3.01	.010
322-34	39.5	495.6	142.1	1.91	24.0	6.88	.007
322-35	24.4	424.2	63.62	1.26	21.9	3.29	.012
322-36	40.6	723.4	117.6	2.13	37.9	6.16	.006
322-37	16.7	131.2	41.8	.87	6.83	2.175	.011
322-38	35.37	423.1	93.65	2.14	25.7	5.68	.007
322-39	33.8	473.8	137.9	1.89	26.53	7.72	.007
322-40	39.9	488.74	120.9	2.29	28.1	6.94	.005
322-41	31.8	372.7	98.46	1.83	21.4	5.66	.008
322-42A_3	33.8	414.0	114.2	--	--	--	--
322-42A_4	29.4	601.1	43.25	--	--	--	--
322-42B_1	28.9	414.7	82.2	1.5	21.6	4.28	.009
322-42B_2	32.1	486.8	81.9	1.69	25.7	4.32	.009
322-42B_3	33.7	735.5	117.9	1.78	38.8	6.22	.0135
322-42B_4	29.36	511.6	44.9	1.6	27.9	2.45	.007
322-42B_5	30.9	588.2	101.76	--	--	--	--

Sample #	$E_s/\rho_{app.}$ in($\times 10^{-6}$)	$\sigma_{cs}/\rho_{app.}$ in($\times 10^{-3}$)	$\sigma_{UTS}/\rho_{app.}$ in($\times 10^{-3}$)	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-6}$)	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-3}$)	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi($\times 10^{-3}$)	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm($\times 10$)
322-42B6	35.8	621.8	46.5	1.93	33.5	2.5	.010
322-45	22.95	228.2	68.86	1.43	14.2	4.28	.010
322-48	17.5	87.9	40.4	0.94	4.7	2.16	.013
322-49A	27.7	462.5	78.48	1.46	24.4	4.14	.008
322-50	21.2	269.57	216.6	1.17	14.8	2.87	.007
322-61	14.96	146.62	37.78	0.79	7.73	1.99	.010
322-62	34.9	475.7	89.95	1.88	25.6	1.84	.006
322-63	46.8	990.87	113.76	2.64	55.85	6.41	.005
322-63A	57.45	565.2	119.3	3.1	30.43	6.42	.005
322-64	54.23	1287.9	152.79	3.13	74.45	8.83	.005
322-64B	56.25	1157.7	176.5	3.27	67.34	10.27	.005
322-67	43.0	1006.2	158.25	2.55	59.6	9.38	.005
322-67B	44.9	941.7	151.2	2.29	47.97	7.7	.006
322-68	19.8	284.3	54.98	1.09	15.61	3.02	.009
322-68A	--	--	--	--	--	--	.009
322-69	16.8	208.6	47.73	0.9	11.3	2.59	.009
322-69A	16.1	201.7	53.05	0.86	10.4	2.82	.010
322-70	15.2	244.3	45.73	0.79	12.7	2.38	.011
323-2	40.8	947.4	153.65	2.14	49.6	8.05	.006
323-2A	45.0	916.8	141.8	2.34	47.7	7.38	.006
323-3A	60.7	1187.9	159.5	3.36	65.7	8.81	.005
323-4	19.5	305.2	66.7	1.04	16.2	3.54	.0093
323-4A	19.5	297.7	61.4	1.04	15.8	3.26	.0095
323-5	[illegible].95	163.4	30.7	0.16	8.85	1.66	.0217
323-5A	2.99	155.3	36.1	0.158	8.19	1.91	.0213
323-7A	5.39	294.0	46.4	0.292	15.9	2.51	.0174
323-8A	7.75	580.1	122.6	0.426	31.9	6.7	.0126
323-9	8.33	338.3	83.3	0.454	18.46	4.54	.0132
323-9A	3.62	329.8	47.3	0.199	18.11	2.60	.0126
323-11B	2.84	192.3	36.3	0.153	10.35	1.95	.0225
323-11E	--	188.5	64.1	--	10.01	3.40	.0218
323-11F	2.207	148.5	31.4	0.121	8.15	1.72	.0211
323-12	6.39	282.9	55.9	0.353	15.63	3.09	.0129

Sample #	$E_s/\rho_{app.}$ in $(\times 10^{-6})$	$\sigma_{cs}/\rho_{app.}$ in $(\times 10^{-3})$	$\sigma_{UTS}/\rho_{app.}$ in $(\times 10^{-3})$	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-6})$	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-3})$	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-3})$	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm$(\times 10)$
323-12A	5.74	171.8	71.5	0.313	9.37	3.90	.0145
323-13	9.54	381.0	66.7	0.527	21.1	3.69	.0118
323-13A	9.48	391.9	61.5	0.524	21.67	3.40	.0116
323-14		402.1	73.8		22.67	4.16	.0092
323-19	3.46	148.1	30.9	0.188	8.03	1.675	.022
323-20	9.12	1028.9	132.9	0.494	55.8	7.2	.0097
323-20A	8.77	675.1	153.2	0.476	36.6	8.3	.0102
323-21	6.92	352.6	91.2	0.355	18.1	4.68	.0129
323-22	9.33	883.4	161.2	0.502	47.6	8.68	.0103
323-23	7.69	287.5	62.1	0.381	14.2	3.07	.0126
323-25	1.43	142.6	28.9	0.077	7.68	1.56	.0258
323-25A	1.49	128.1	22.3	0.079	6.8	1.18	.0202
323-26	6.51	434.0	72.9	0.346	23.1	3.88	.0133
323-26A	6.23	386.9	76.4	0.329	20.4	4.03	.0137
323-27		371.0	84.8		19.4	4.44	.0319
323-28	6.16			0.318			.0145
323-28A	5.42	262.0	47.8	0.282	13.6	2.49	.0171
323-29		157.4	13.4		8.4	.71	.0307
323-31		310.9	69.2		15.3	3.4	.0123
323-32	5.99	312.9	75.2	0.316	16.5	3.97	.0147
323-32A	6.32		83.3	0.331		4.37	.0143
323-34		304.98	67.6		15.98	3.54	.0114
323-35A	7.07	316.8	68.9	0.368	16.5	3.58	.014
323-36A	3.3	224.7	102.9	0.175	11.9	5.5	.018
323-36	6.05	360.5	80.5	0.328	19.5	4.36	.014
323-38		332.1	79.9		18.4	4.42	.012
323-39	1.03	388.6	65.4	0.45	20.2	3.40	.012
323-40	3.13	336.1	66.1	0.312	17.9	3.51	.013
323-41		130.5	53.4		7.02	2.87	.015
323-43		298.8	34.6		15.98	1.85	.014
323-45	5.06	246.4	71.6	0.274	13.4	3.88	.015
323-46	5.95	337.2	84.9	0.325	18.4	4.63	.014

Sample #	$E_s/\rho_{app.}$ in$(\times 10^{-6})$	$\sigma_{cs}/\rho_{app.}$ in $(\times 10^{-3})$	$\sigma_{UTS}/\rho_{app.}$ in $(\times 10^{-3})$	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-6})$	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-3})$	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-3})$	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm$(\times 10)$
323-47		284.4	101.9		15.2	5.45	.013
323-48	6.36	356.3	85.9	0.345	19.3	4.66	.013
323-50	8.72	1071	137.8	0.476	58.4	7.52	.009
323-54		308.1	56.3		16.1	2.95	.011
323-55	6.36	384.9	40.7	0.340	20.6	2.18	.013
323-56		432.1			22.6		.010
323-57	6.05	315.2	51.2	0.337	17.5	2.85	.013
323-58	4.32	257.8	70.1	0.240	14.3	3.9	.016
323-65	5.99	324.9	79.4	0.320	17.4	4.25	.013
323-66	6.46	244.5	76.6	0.347	13.16	4.12	.014
323-67	12.27	1189.9	209.7	0.643	62.34	10.99	.009
323-68		250.8	63.5		13.8	3.5	.016
323-69	5.57	248.1	70.1	0.299	13.36	3.77	.013
324-1	4.54	209.4	59.6	0.245	11.3	3.21	.015
324-2	5.68	223.5	46.6	0.297	11.71	2.44	.015
324-3	6.19	301.7	79.2	0.340	16.6	4.35	.013
324-4	10.9	704.5	136.1	0.599	38.7	7.48	.009
324-5	4.43	248.4	73.4	0.243	13.6	4.03	.014
324-6	4.61	249.8	90.1	0.255	13.81	4.98	.015
324-7	4.61	269.7	80.9	0.246	14.1	4.33	.016
324-8	4.86	269.7	77.7	0.267	14.8	4.27	.015
324-9		249.4	74.7		13.8	4.13	.015
324-11	8.98	806.8	122.2	0.496	44.6	6.75	.009
324-12	8.05	579.3	97.2				
324-13	9.62	938.8	153.2	0.521	50.9	8.30	.009
324-14	12.70	1190.9	192.7	0.651	61.1	9.89	.009
324-15	6.98	465.0	100.6	0.373	24.9	5.38	.010
324-16	10.24	836.4	127.3	0.799	44.4	6.76	.008
324-18	12.02	1179.8	174.7	0.678	66.5	9.85	.008
324-19	6.30	496.2	80.4	0.351	27.6	4.47	.012
324-20	5.34	476.8	65.6	0.287	25.67	3.53	.014

Sample #	$E_s/\rho_{app.}$ in ($\times 10^{-6}$)	$\sigma_{cs}/\rho_{app.}$ in ($\times 10^{-3}$)	$\sigma_{UTS}/\rho_{app.}$ in ($\times 10^{-3}$)	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi ($\times 10^{-6}$)	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi ($\times 10^{-3}$)	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi ($\times 10^{-3}$)	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm ($\times 10$)
324-21	12.93	1225.0	133.0	0.696	65.9	7.16	.008
324-21A	12.4	994.3	13.2	0.661	53.2	7.04	.009
324-22		718.7	115.0		40.2	6.44	.011
324-23	8.42	410.6	66.5	0.462	22.55	3.65	.013
324-24	7.16	439.8	67.1	0.401	24.6	3.76	.012
324-25A	9.06	933.1	131.8	0.367	37.8	5.33	.010
324-25B	1.44	110.3	15.5	0.077	5.94	.834	.034
324-25C	3.33	142.9	17.2	0.180	7.74	.932	.019
324-25D		699.2	147.2				
324-26	12.73	1240.8	157.8	0.708	69.04	8.78	.008
324-27A	3.47	196.8	37.0	0.192	10.9	2.05	.014
324-27B	.387	25.4	5.54	0.0218	1.43	.374	.035
324-27C		25.4	5.54		1.41	.308	.048
326-27D		20.8			1.15		.038
324-29	3.63	107.6	26.3	0.189	5.60	1.37	.015
324-32	4.46	154.7	57.4	0.248	8.61	3.20	.015
324-33	7.90	786.5	118.1	0.428	42.6	6.4	.009
324-34	8.41	602.4	109.6	0.477	34.2	6.2	.009
324-35	5.71	273.6	57.9	0.322	15.42	3.3	.013
324-37	6.04	229.1	58.2	0.319	12.1	3.07	.012
324-38	6.10	286.5	61.0		15.4	3.28	.014
324-39	5.35	248.8	62.6	0.292	13.6	3.41	.016
324-40A	3.27	149.3	31.7	0.181	8.25	1.75	.016
324-40D	.60	294.8	63.8				
324-40E	6.53	181.6	31.7	0.337	9.38	1.64	.012
324-41	5.91	314.1	72.8	0.320	17.0	3.94	.013
324-42	5.66	191.0	64.8	0.303	10.2	3.46	.012
324-43	7.64	334.4	97.2	0.425	18.6	5.41	.011
324-44	5.17	361.9	63.3	0.282	19.7	3.45	.012
324-45	8.12	361.0	104.4	0.446	19.8	5.73	.011
324-46	6.36	222.1	76.7	3.66	12.76	2.77	.01
324-47	5.01	180.2	45.1	0.271	9.77	2.44	.013

Sample #	$E_s/\rho_{app.}$ in $(\times 10^{-6})$	$\sigma_{cs}/\rho_{app.}$ in $(\times 10^{-3})$	$\sigma_{UTS}/\rho_{app.}$ in $(\times 10^{-3})$	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-6})$	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-3})$	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-3})$	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm$(\times 10)$
324-48	6.02	291.8	74.3	0.346	16.8	4.27	.011
324-51	13.7	938.8	159.6	0.766	52.2	8.88	.008
324-52	6.09	266.8	58.1	0.33	14.5	3.15	.012
324-56	5.65	247.7	74.3	0.292	12.8	3.83	.014
324-57	11.98	572.2		0.632	30.18		.009
324-58	8.45	243.6	63.2	0.467	13.46	3.49	.011
324-61	10.91	331.07	92.9	0.572	17.34	4.87	.009
324-62	6.77	254.2	15.3	0.36	13.50	3.81	.013
324-63	7.57	287.8	56.8	0.413	15.7	3.10	.013
324-65	4.44	232.7		0.255	13.4		.014
324-66	2.61	132.9	30.8	0.147	7.49	1.74	.016
324-67	4.31	265.1	54.1	0.247	15.2	3.11	.014
324-69	4.26	226.7	46.5	0.236	12.5	2.55	.0146
324-70	4.20	224.2	51.2	0.235	12.6	2.77	.0139
324-71	5.71	242.7		0.287	13.5		.0135
324-72	2.31	101.5	20.8	0.129	5.68	1.12	.0163
325-1	9.44	977.8	111.7	0.518	53.7	6.1	.0094
325-5		254.3	49.4		14.1	2.75	.015
325-6		998.7	176.6		50.5	8.93	.018
325-7		333.9	83.4		18.5	4.6	.008
325-10C		251.1	57.8		13.8	3.18	.022
325-11							.020
325-12							.014
325-13							.010
325-14							.011
325-18A							
325-18B							
325-18C							
325-19A							
325-19B							
325-19C							
325-20							

Sample #	$E_s/\rho_{app.}$ in $(\times 10^{-6})$	$\sigma_{cs}/\rho_{app.}$ in $(\times 10^{-3})$	$\sigma_{UTS}/\rho_{app.}$ in $(\times 10^{-3})$	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-6})$	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-3})$	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-3})$	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm$(\times 10)$
325-21							.014
325-22							.012
325-23							.013
325-24							.013
325-26							.018
325-28		280.7	64.9		16.3	3.78	.017
325-31							.014
325-32							.014
325-33							.015
325-35		230.8	52.5		12.83	2.92	.019
325-36							.015
325-38							.018
325-39							.016
325-41							.017
325-42		265.4	43.5		14.7	2.40	.019
325-43		190.7	44.1		10.96	2.53	.020
325-44							.012
325-45		152.1	35.9		8.30	1.96	.016
325-47							.015
325-48		196.4	43.4		10.8	2.38	.019
325-50							.014
325-51							.016
325-54		210.6	42.8		14.5	2.47	.015
325-55		441.3	85.7		24.6	4.8	.013
325-55A		187.3	44.9				
325-56		635.7	119.5		33.9	6.4	.010
325-57		235.2	51.9		13.3	2.9	.015
325-57A		286.7	53.6		16.1	3.0	.015
325-58		174.4	39.6		9.6	2.18	.017
325-58A		258.9	58.1		14.2	3.19	.016
325-59		98.2	21.5		5.4	1.18	.013
325-59A		97.0	25.0		5.6	1.45	.012
325-59B		282.6	62.1		15.3	3.37	.014

Sample #	$E_s/\rho_{app.}$ in $(\times 10^{-6})$	$\sigma_{cs}/\rho_{app.}$ in $(\times 10^{-3})$	$\sigma_{UTS}/\rho_{app.}$ in $(\times 10^{-3})$	$E_s\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-6})$	$\sigma_{cs}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-3})$	$\sigma_{UTS}\left(\frac{\rho_{real}}{\rho_{app.}}\right)$ psi $(\times 10^{-3})$	$\rho\left(\frac{\rho_a}{\rho_{He}}\right)$ Ω-cm$(\times 10)$
325-59C		363.9	59.9		19.2	3.16	.014
325-60		271.4	55.7		14.8	3.04	.015
325-60A/W		168.5	39.4		9.25	2.16	.018
325-61		304.2	72.9		16.5	3.95	.015
325-61A		237.4	65.6		12.9	3.6	.014
325-61B		283.8	65.8		15.2	3.52	.013
325-61C		199.1	44.2		10.6	2.35	.016
325-61D							.018
325-61E							.016
325-62							.013
325-62A							.014
325-62B							.012

TABLE 11 Comparison of Ultimate Strength Determined by Direct Tension vs. Disc Rupture

Sample #	Direct Tension	Disc Rupture
317-38	3780 psi	5100 psi
318-59	4600 psi	4153 psi
321-16B	5306 psi	4705 psi
321-36A	4081 psi*	2462 psi
321-50B	3780 psi	5228 psi
322-23B	3163 psi	4050 psi
322-24A	1367 psi	1279 psi
322-24B	1122 psi	1279 psi

*Broke in Grip

TABLE 12 Comparison of Sonic Modulus and Mechanical Modulus

Sample #	HTT Temp. °C	Mechanical Modulus	Sonic Modulus
317-8	2000	1.27×10^6	1.82×10^6
317-26	2000	0.38×10^6	0.31×10^6
317-42	2000	1.4×10^6	1.5×10^6
317-46	2000	1.59×10^6	1.27×10^6
318-17	2000	1.16×10^6	1.18×10^6
318-52	2000	2.0×10^6	1.69×10^6
321-12	2000	1.01×10^6	1.22×10^6

TABLE 13 Sonic Modulus vs. Pyrolysis Temperature

psi($\times 10^{-6}$)

Sample #	700°C	800°C	900°C	1000°C	1577°C	1800°C	2000°C
318-59 #1L	1.02	--	--	2.16	1.95	1.77	1.46
318-59 #2L	1.06	--	--	2.07	2.10	1.82	1.76
318-60L	.93	--	--	--	1.82	1.77	1.70
321-11L	.75	--	--	2.37	1.68	1.72	1.58
321-11CL	.73	--	--	1.75	1.75	1.72	1.66
321-12L	.66	--	--	1.49	2.03	1.23	1.18
321-13 #1L	.80	--	--	1.84	1.77	1.73	1.75
321-13 #2L	.82	--	--	1.84	--	1.79	1.72
321-13 #3L	.88	--	--	1.91	--	1.75	1.72
321-15 #1	.81	--	1.69	1.92	1.91	1.84	1.69
321-15 #2	--	1.53	--	1.96	2.01	1.86	1.71
321-15L	--	1.69	--	2.06	1.875	1.86	1.79
321-16A	--	1.60	--	1.88	1.87	1.70	1.55
321-16AL	--	1.57	--	1.97	1.87	1.67	1.58
321-16B	--	1.68	--	1.87	1.68	1.55	1.48
321-17B	.80	--	1.80	2.12	1.96	1.91	1.81
321-18A	--	1.63	--	2.2	2.14	2.09	1.98
321-18B #1	--	1.73	--	1.48	1.86	1.81	1.73
321-18B #2	--	1.52	--	1.97	2.09	1.74	1.73
321-18BL	--	1.56	--	1.60	1.90	1.83	1.75
321-19A	--	1.53	--	2.03	1.96	1.89	1.83
321-19B #1	.75	--	3.27	1.58	1.78	1.49	1.49
321-19B #2	--	1.32	--	1.69	1.61	1.61	1.55
321-19BL	--	1.40	--	2.15	1.63	1.64	1.55

TABLE 14 Resistivity vs. Pyrolysis Temperature

Ω-cm(×10)

Sample #	800°C	900°C	1000°C	1577°C	1800°C	2000°C
318-59 #1L	--	--	.499	.102	.083	.110
318-59 #2L	--	--	.522	.099	.081	.060
318-60L	--	--	.523	.0108	.016	.170
321-11L	--	--	.643	.116	.120	.120
321-11CL	--	--	.471	.098	.090	.170
321-12L	--	--	.542	.148	.120	.06
321-13 #1L	--	--	.506	.120	.170	.100
321-13 #2L	--	--	.521	.106	.160	.110
321-13 #3L	--	--	.490	.111	.110	.110
321-15 #1	--	.143	.014	.0302	.015	.015
321-15 #2	.448	--	.029	.0319	.015	.015
321-15L	.324	--	.110	.115	.170	.110
321-16A	.279	--	.014	.029	.015	.015
321-16AL	.366	--	.170	.089	.120	.100
321-16B	.445	--	.030	.0328	.017	.017
321-17B	--	.083	.080	.0357	.018	.018
321-18A	.238	--	.047	.0333	.017	.017
321-18B #1	.611	--	.059	.0334	.016	.016
321-18B #2	.302	--	.03	.0325	.016	.016
321-18BL	.374	--	.160	.114	.110	.110
321-19A	.317	--	.031	.0332	.017	.017
321-19B #1	--	.171	.017	.0368	.018	.018
321-19B #2	.302	--	.03	.0325	.016	.016
321-19BL	.355	--	.150	.081	.110	.110